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## THE SOLAR PROMINENCE OF JANUARY 7, 1916.

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A series of eleven photographs of this prominence was obtained with the Rumford spectroheliograph between $10^h\ 7^m$ a. m. and $1^h\ 15^m$ p. m. January 7, 1916. All were taken with light from the center of the H line of calcium. The disturbance took place over an arc of 17 degrees or 207,000 km along a meridian between points having position angles 56° and 73°. The center of the disturbance was at P. A. 65°.

In the first photograph taken at G. M. T. $4^h\ 7^m$ (Plate VIII) the denser masses of gas are evidently falling toward the south while the more rare portionsretain their position and combine with the northward streamers to form the faint arch shown at G. M. T. $4^h\ 52^m.5$. At this time a new eruption is also shown projected up through the base of the first column but at a widely different angle, being inclined only about 40° to the tangent to the limb at its base. At G. M. T. $5^h\ 26^m$ the point of this eruption has travelled through a distance of 85,000 km at a rate of 42 km per second and at an elevation of 35,000 km from the surface of the sun. At G. M. T. $7^h\ 3^m$ the higher lying masses have become detached from the lower and are dissipating while drifting outward and toward the south.

Throughout the development of the prominence there is evidence of a moderate north wind in this region so that the low angle eruption shown in the second and third photographs, taking place against the wind, indicates that a tremendous expulsive force has operated. Another photograph taken the next day January 8 at G. M. T. $5^h\ 3^m$ through a very hazy sky shows low faint prominences at the seat of the previous day's activity.

Neither the flocculus plate of January 7 nor that of the next day shows any indication of disturbance in this region and cloudy weather on many succeeding days prevented observations of the effected area in better projection.

# THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 162.*]

In the bitter quarrel which later followed between Scheiner and Galileo, both claiming the honor of the discovery of the spots, one looks in vain for the name of Fabricius. After finishing the unpleasant literature of this quarrel one realizes that he has not been concerned so much with the record of the actual events, as with a bitter strife in which the personal element predominates more than one would wish. To judge hastily one might well believe that the two principals were both ignorant of the work of Fabricius. But this seems hardly possible. Berthold maintains that both Galileo and Scheiner must have intentionally suppressed the name of Fabricius. It has been remarked that the Book Catalogue of the Fair came into the hands of all the learned men of the day, and the title of the *Narratio* would have been too attractive for either of them to have overlooked it. We recall also in passing, the *Prognosticon Astrologicum* for 1615, which contains information concerning the first observation of the solar spots, and particularly specifies Johann Fabricius as the first observer, while Apelles is only mentioned afterwards. However, it is possible that these may have been overlooked. But there is other evidence which would seem to prove unquestionably that neither Scheiner nor Galileo could have been ignorant of the name or discovery of Fabricius.

We first mention the *Mundus Jovialis* of Simon Mayr which appeared in 1614. This book is mentioned by Galileo in the *Saggiatore*,* and by Scheiner in the *Rosa Ursina*;† and we recall that Mayr refers to the two Fabricii as the first discoverers and observers of the solar

* *Gal. Op.* **6**, 215.

† Lib. I. p. 28, and Lib. II. p. 741.

spots. Secondly, we have the *Ephemerides Novae Motuum Coelestium* for the year 1617, by Kepler, published at Linz in 1618. And indeed one cannot well believe that either Galileo or Scheiner could have been ignorant of it. Kepler writes in the *Responsio ad Interpellationes Davidis Fabricii*:*

.....that the sun-spots were seen by your son, long before Apelles, if you are satisfied; and these proofs I have testified to many people at Prague, and I testify even now.

In addition to this, it seems that Scheiner was actually in correspondence with David Fabricius. The *Calendarium Historicum* contains the statement:†

1612, Scheiner, a Jesuit writes on the 29th day of October, (which was the evening of the lunar eclipse), all that 29th day the sky was very clear.

There can be no doubt that Fabricius' observations and the pamphlet that he published concerning them were known in Rome by the Jesuits and other friends of Scheiner. Kepler writes to Maelcote on the 18th of July 1613, describing his methods of observing the spots and mentions:‡

A certain Fabricius of Wittenberg,.....who published a book about this thing in June 1611, whom a certain man from Agusta [Augsburg] followed, either anonymously or with the assumed name of Apelles.

From this evidence, the assertion that both Galileo and Scheiner knew of Fabricius and the *Narratio*, certainly seems justified; but whether the suppression of Fabricius' name was intentional, as is maintained by Berthold, or whether Galileo and Scheiner were so occupied with their own affairs that Fabricius and his *Narratio* were immediately forgotten, is not apparent. The former is certainly possible, but the latter explanation seems the more probable.

Evidently the *Narratio* was not well known even in Germany, for it is mentioned only occasionally. There is but one notice of it during the seventeenth century, (quoted above). However, it became better known after the beginning of the eighteenth, for we now find several references to it. One in 1709;¶ another in the portion of Kepler's correspondence published by Hanchius in 1718.‖ But the credit for completely resurrecting the *Narratio* from the dust of the library belongs to Christian Wolff, who, recovering and reading the pam-

* *Kepleri Opera Omnia*, **2**, 785.

† *Astronomische Nachrichten*, **31**, 133.

‡ *Gal. Op.* **11**, 537.

¶ Jo. Bernardi Widiburgii *Dissertatio de maculis solaribus*...Helmstadtii, 1709.

‖ *Joannis Kepleri aliorumque epistolæ mutuae.* Lipsiae, 1718. p. 557.

phlet, placed the author in his rightful position. In his *Vernünfftige Gedancken von den Würckungen der Natur*,* we find the following statement concerning Fabricius:

After Galileo with his telescope had discovered many wonderful things, which he announced with his Nuncio Sidereo in 1610, among which were the satellites of Jupiter, and the innumerable hosts of stars, invisible to the naked eye, Johann Fabricius, the son of the celebrated astronomer David Fabricius, was aroused to observe the heavens with the telescope himself. With this object he brought one with him from Holland, and while he was sojourning with his father in East Friesland was desirous of observing the sun, and was fortunate in at once seeing spots on it, which he also showed to his father. He applied himself with all energy to this, so that he confirmed by many observations that which he had noticed in the first spots perceived in the sun; and continued observing from the beginning of the year up to the first of June; at which time the observations were sent to the press at Wittenberg at which place they were published in the same year. In this same year the celebrated Jesuit, Christoph Scheiner saw spots in the sun, as in the month of May he was examining the sun with his telescope for another purpose; which observations were published by Mark Welser under the title *Apelles post Tabulam*, because Theodore Busaeus, the provincial of the Jesuits, hesitated to give [Scheiner] permission to publish this under his own name. Through this Galileo was aroused so that in 1612 he at once observed spots on the sun, and afterward published an important tract concerning them.

While perhaps Wolff's remarks concerning Galileo and Scheiner are not altogether correct, this mention of Fabricius and his pamphlet served to attract attention to him, and to bring his name before the astronomical public.

There is no mention of the *Narratio* or of its author in any biographic or bibliographic repertory published previous to Weidler. He refers to it in his *History of Astronomy*, published in 1741 in the following words:†

It is not to be kept silent that at about the same time as Scheiner, Johann Fabricius saw spots on the sun here at Vitemberg. He brought with him a new telescope from Batavia, and having turned it toward the sun, he saw spots; which he subsequently observed more diligently, examining their motions. He published at Wittemberg 1611 idib. Juni 4 narrationem de maculis in sole observatis.....

Naturally Weidler inserted Fabricius' pamphlet in his *Astronomical Bibliography*,‡ and thus being included in the materials proper of the history of the science it was mentioned by Montucla.¶ In this way it became known to De la Lande, who gives a short synopsis of the few pages that are concerned with the solar spots.‖ Thus the knowledge of it has come down to us at the present time.

* Halle in Magdeburg, 1723.
† Jo. Friderici Weidleri, *Historia Astronomia*,.....Vitembergae, 1741.
‡ Jo. Friderici Weidleri, *Bibliographia Astronomica*,..... Wittenbergae, 1755.
¶ *Histoire des Mathematiques*, Paris, 1758. **2**, 311
‖ *Histoire de l'Academie Royale des Science*; Paris 1778. p. 395. Also in his *Astronomie*; Paris, 1792. **3**, 278.

According to Berthold* there are but seven copies of the *Narratio* still in existence. These are in various libraries in continental Europe.

### Christopher Scheiner and the Letters on the Solar Spots.

Christopher Scheiner was born in Walda, in Swabia in 1573. Early designed for the priesthood, he attended the Jesuit Latin School at Augsburg, then continuing his studies at the Jesuit College at Lansberg, he entered the order in 1595. Scheiner was then sent to the Hochschule at Ingolstadt where he applied himself to the study of the mathematical sciences and soon obtained the Master's degree. After obtaining this, he was sent in 1603 to Dillingen to assist with the teaching at the Jesuit Academy at that place. While Scheiner was at Dillingen he invented an instrument which alone would have been sufficient to insure his name to posterity. This instrument was the well-known pantograph. Upon leaving Dillingen, Scheiner returned to the Hochschule at Ingolstadt to continue his theological studies. In 1610 he was appointed Professor of Mathematics and Hebrew at the University of Ingolstadt. He remained at Ingolstadt for six years, observing the spots on the sun and devoting his time to scientific investigations. Leaving Ingolstadt, Scheiner went to Innsbruk and in the following year entered the priesthood. In 1620 he became Professor of Mathematics in the Jesuit College at Freiburg in Breisgau. Three years later Scheiner was named as Superior of the proposed Jesuit College at Neisse in Silesia, and a short time later became Rector. Scheiner went to Rome in connection with the affairs of this college in 1624, remaining there nine years. It was during his stay in Rome that Scheiner published his great book, the *Rosa Ursina*. Recalled by the Emperor Ferdinand II, Scheiner went to Vienna where he remained until 1639. From Vienna he returned to Neisse where he died in 1650.

Scheiner's announcement of his first observations was made in his first letter to Mark Welser. These letters to Welser, it will be remembered were signed with the assumed name, "Apelles Latens Post Tabulam." The reason for the anonymous publication is given by "Apelles" himself, namely, that the provincial of the Order would only permit the announcement of the discovery when made under a fictitious name.†

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* *Op. Cit.* p. 23.

† It is related that when Scheiner had communicated his discovery to Theodore Busaeus, the provincial, the latter refused to credit his assertions, "I have read my Aristotle from end to end many times", he remarked to Scheiner, "and I can assure you that I have never found in it anything similar to what you mention. Go, my son, calm yourself, and be assured that what you take for spots on the sun are the faults of your glasses or your eyes." (Montucla, *Histoire des Mathematiques.* 2, 312.)

In the first letter which is dated the 12th of November 1611, Apelles writes:*

> About seven or eight months ago (ante menses septem, octo circiter), I, together with a friend of mine, directed toward the sun an optic tube, which magnified about six or eight hundred times in area, to compare its [the sun's] apparent size with the moon, and we found them both to be the same. And while we were intent on this matter, we noticed certain black spots like darkish drops on the sun; but at that time our examination was not carefully made, thinking it to be a matter of no importance we postponed observations until another time. And thus we returned to this matter last month, October, and we found on the sun, apparently, spots, about as you see them pictured. Since this thing was hardly to be believed, we doubted at first whether it was not some fault of the eyes or of the tube, or of the atmosphere. Therefore we availed ourselves of the eyes of many peple, who all without exception saw the same things in the same place and in the same number. We concluded therefore, that the fault was not in the eyes, for how could it happen that the eyes of so many people should suffer from a similar affliction, which on certain days should change for another.

Scheiner continues, discusssing the impossibility of the spots being in the eyes of the observer, or in the telescope. Eight different telescopes were used and all showed the same spots in the same arrangement; revolving the telescope on its axis did not change the positions of the spots and this showed that they were not caused by it. From the lack of parallax it was concluded that the spots were not in the atmosphere of the earth, and since they are evidently real bodies of some sort they must be in the sun or in the heavens around it. If the spots are in the sun, it indicates that the sun rotates (for the spots move) and hence the spots should reappear; but since this does not happen, the sun does not rotate. Therefore the conclusion is that the spots are not in the sun, but are bodies (stellae) which come between us and the sun, and hence circulate around it. The appearance of individual spots is described (accompanied by drawings), and the letter concludes with a rather detailed account of the various methods of observing the spots. In this letter, Scheiner clearly shows the influence of the prevailing opinions of the time regarding the purity of "the Eye of the World", and of the admonitions of Busaeus. He retained his belief that the spots were planetary bodies circulating around the sun for many years, only relinquishing it when forced to do so by the evidence of his own observations.

In the second letter,† dated 19th of December 1611, Apelles describes a supposed inferior conjunction of Venus. He calculated according to the ephemeris of Magini, that Venus would be at inferior conjunction on December 11th, transiting the sun's disk as a black spot about 3′ in

* *Gal. Op.* **5**, 25.
† *Gal. Op.* **5**, 28.

diameter, with a motion opposite to that of the spots. According to the calculation the transit should begin on the night of December 11th, continuing until the afternoon of the 13th. The 12th was entirely cloudy, but the next day dawned bright and clear; Venus, however, failed to make the expected appearance. Apelles thereupon concluded that Venus was on the other side of the sun, and thence dared to propose, contrary to the accepted Ptolemaic theory, that Venus revolved around the sun. The letter, which is short, has to do with the spots only in that Apelles argues from analogy to these that Venus revolved around the sun.

In the third letter,* dated the 26th of December in the same year, Apelles discusses in more detail the observations which he had made up to date, and speaks with more assurance. He asserts that the spots are not in the sun; they require about fifteen days to transit the disk, and hence should reappear after an equal interval, but since they fail to do this they cannot be in the sun, "Impossibile itaque est, ut ulla Soli insit. Ubi ergo?" The spots are not in the atmosphere, nor in the region of the moon, nor of Venus, nor of Mercury, therefore they must be near the sun. Since they are not clouds or comets, it remains that they are bodies (stellae) which are solid and opaque. He explains the changes of shape and figure near the sun's edge as due to phases like the moon. He states that the spots are not far distant from the sun, they are of sufficient size or they would be swallowed up by irradiation, also they are very opaque and thick. They are compared to the satellites of Jupiter in that they surround the sun as the satellites do their primary. The letter concludes with the statement that between the sun and Mercury there ought to be a number of planets, and consequently we would see them when passing between the earth and the sun.

Accompanying the three letters is a series of drawings showing the appearance of the sun and spots from the 21st of October to the 14th of December 1611. (Plate IX).

All three of these letters were published by Welser at Augsburg, under the title *TRES EPISTOLAE DE MACVLIS SOLARIBVS. Scriptae ad MARCVM VELSERVM. AVGVSTAE VIND. II. VIRVM PRAEFECT.....ANNO M. DC. XII. Non. Ian.* (Plate X). The book appeared on the 5th of January 1612. On the following day Welser forwarded a copy to Galileo with this letter:†

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* *Gal. Op.* **5**, 28.

† *Gal. Op.* **11**, 257.

"The Kingdom of Heaven suffers violence, and violent people are destroying it." You were the first to scale the height and carried off the mural crown. After you others follow with greater courage, because they know that it would show cowardice not to second such happy and honorable enterprise. Now that you have once broken the ice, see what this friend of mine has risked; and, if as I believe, it will not be entirely new to you, I am hoping that you will be pleased to see that also on this side of the mountains there are not lacking those to follow in your footsteps.

Apparently there was some delay in the transmission of the book. Prince Cesi mentions it for the first time on March 3, 1612.* Galileo at this time was seriously ill, and consequently did not reply with his usual promptness, so that Welser wrote again on the 23rd of March,† urging a reply.

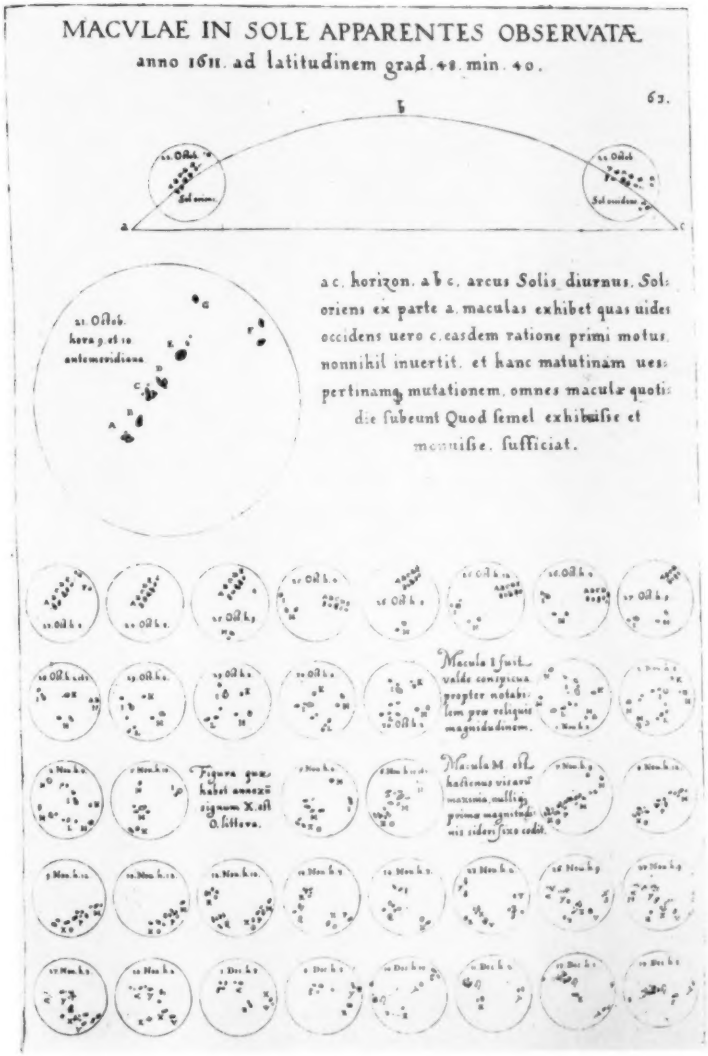
In the meantime, and certainly before receiving the copy of the *Tres Epistolae*, Galileo had referred to the solar spots, questioning their nature as already quoted (page 89) in the *Discorso*. The publication of this was sanctioned by the Holy Office on March 5th, and it finally appeared during the latter part of the month of May.

To the *Tres Epistolae* of Apelles, Galileo replied with two letters addressed to Welser, giving the details of his observations and explaining his theory of the spots.

In the first letter,‡ dated May 4, 1612, Galileo gives his reasons for not making an earlier announcement of the discovery of the spots; as already quoted, these are, his uncertainty of the nature of the spots, and the fear of attracting the wrath and enmity of the Peripatetics. The observations made during eighteen months have convinced him that the spots are real and not the fault of the eyes or of the glasses. The movement of the spots is from east to west and from south to north (the opposite was claimed by Apelles); that is, similar to the motion of Mercury and Venus at inferior conjunction and around the sun. The absence of parallax indicates that the spots are not near to the earth, but are far distant from it, and hence near to the sun. The spots are not exterior to the sun, as was held by Apelles. They are not solid bodies like the moon and the other planets, but are less solid and less dense; their appearance and behaviour resembling more that of clouds passing between us and the sun. Apelles believed that it could be proved by a comparison of the spots with Venus that the latter and Mercury revolved around the sun. Galileo expresses surprise that Apelles does not know of the discovery of the phases of Venus two years before, or that if he is aware of it, why he does not make use of this discovery which no longer permits any doubt of, but

* *Gal. Op.* **11**, 280.
† *Gal. Op.* **11**, 289.
‡ *Gal. Op.* **5**, 94.

PLATE IX


MACVLAE IN SOLE APPARENTES OBSERVATÆ.
anno 1611. ad latitudinem grad. 28. min. 40.
62.
b
a
c
Sol ortus.
Sol occidens.
21. Octob. hora 9. et 10 antemeridiana.
a c. horizon. a b c. arcus Solis diurnus. Sol oriens ex parte a. maculas exhibet quas uides occidens uero c. eadem ratione primi motus nonnihil inuertit. et hanc matutinam uespertinamq; mutationem. omnes maculæ quotidie subeunt Quod semel exhibuisse et monuisse. sufficiat.
Macula I fuit valde conspicua propter notabilem prae reliquis magnitudinem.
Figura quæ habet annexũ signum X. est O. hiberna.
Macula M. est hactenus visarum maxima, nullius prima magnitudine, uix sidere sexto cedit.

DRAWINGS OF SUN AND SPOTS ACCOMPANYING THE *Tres Epistolae*, AS REPRODUCED IN THE *Rosa Ursina*.

PLATE X

TRES EPISTOLAE

# DE MACVLIS SOLARIBVS.

Scriptæ ad

MARCVM VELSERVM.

AVGVSTÆ VIND. II. VI. RVM PRÆFECT.

Cum obſeruationum iconismis.

AVGVSTAE VINDELICORVM,
Ad inſigne pinus.
*Cum Priuilegio Cæſ. perpet.*
ANNO M. DC. XII. Non. Ian.

REDUCED FAC-SIMILE TITLE PAGE OF *Tres Epistolae*.

absolutely demonstrates the revolution of Venus around the sun, in accordance with the views of Pythagoras and Copernicus.

Galileo then discusses the opinions expressed by Apelles in his third letter. He states that the spots are not permanent, for some of them disappear while still on the sun's disk. The changes in the velocity of the spots at different points on the disk is explained as a result of the spots being attached to the body of the sun; for if the spots were far distant from it the differences in the velocities would then be imperceptible to our senses. Galileo expresses the need of accurate observations of this velocity in order to determine definitely the positions of the spots.

Concerning the assertions of Apelles that the spots are not clouds or comets, Galileo is not certain, and remarks that the material of which the spots are composed may be unknown to us and hence we can form no conclusion as to what it is:

> "I am quite certain that the material of which the spots are made may be anyone of a thousand things which are unknown to us, and about which we can have no opinion; and the changes that we have observed, that is, in the shape, the density, and the motion, which are the most common, can give little or no information, and that little only of a general sort; so that I cannot believe that the philosopher will be blamed who confesses that he does not know, or cannot know what may be the material composing the spots on the sun." But from analogy to substances with which we are familiar, in absolute contradiction to Apelles, no matter what the material of the spots may be, it is not similar to that of stars, but more similar to that of our clouds. This similarity is noticed, because the spots are produced in shorter or longer time, they unite and separate noticeably from day to day, they change their forms, the majority of which are very irregular, their darkness increases and decreases; and as they are in the sun or in close proximity to it it follows that they must be of great size because they are able to obstruct the light of the sun. Sometimes many are produced, and sometimes only a few, and sometimes none at all. In some parts the spots are dense and more opaque and in others less so, in which respect they resemble nothing as much as our clouds. If the earth were less luminous and received no light from the sun, and if it could be observed from a great distance, it would present a similar appearance.

As evidence for these statements Galileo gives drawings of a spot observed early in the month of April and again on its return in May. The drawings* show the changes in the spot during this interval; and it is to be noted, the drawings also show that Galileo had observed the distinction between the umbra and the penumbra of the spots. From these observations and others which he mentions, he again expresses the opinion that the spots are similar in nature to our clouds:

* Reproduced *Gal. Op.* 5, 107.

I do not for that affirm that such spots are made of the same substance as are our clouds, which are made of water-vapor exhaled from the earth and attracted by the sun, but I only wish to state that we know of nothing that the spots so much resemble, whether they are vapor, or exhalations, or clouds, or smoke produced by the solar body, or attracted by it from all sides. I am not yet sure, for there are thousands of things that we are not yet acquainted with.

From all the evidence Galileo remarks that the name of stars (stellae) does not suit the spots, for if they were such, either moving or fixed, they would always retain their spherical figure, they would not disappear and reappear, but would always remain the same, they would have a certain movement and period, after which they should reappear the same as before. But they do not reappear the same, and certain ones even disappear when on the face of the sun.

The final conclusion, which Galileo expresses rather as an opinion than as a statement of fact (quoted on page 93), is that the spots are not stars, nor do they move around the sun in separate paths at a distance from it; but that the spots are produced and disappear at the solar surface, that they are attached to it, and that the sun in its revolution carries them around with it.

Regarding the probability of the existence of other planets between Mercury and the sun, Galileo believes that while it is possible, it is however unlikely, for no such planets have been seen. The movements of such planets would be uniform and more rapid than those of the spots, because, being nearer to the sun than Mercury and in agreement with the motions of the other planets, they should move faster and have a shorter period than it. As Mercury requires six hours to transit the sun's disk, another planet nearer to the sun and hence moving more rapidly would require less time than this. Since the spots require a much longer time than this, it is not likely that they are planets.

In concluding this letter, Galileo speaks of the unknown Apelles (whose true identity he apparently first became acquainted with two years later*) with the greatest esteem, as a man characterized by a free and unfettered mind. He voices also the hope that he will be enabled to become personally acquainted with him, as he recognizes him as a man of high genius and a lover of truth. Galileo states also that he will soon forward more detailed observations.

The more detailed observations were included in a second letter,† dated August 14, 1612, but not forwarded until the 23rd of the month. In this letter Galileo states that his recent observations have fully confirmed his earlier conclusions. He affirms that the spots are at the surface of the sun, or, if not, the distance is so small that it is

* *Gal. Op.* **12**, 29.
† *Gal. Op.* **5**, 116.

imperceptible. The spots are not stars, or bodies of long duration, for some disappear and new ones come forth. Their duration is from 2 to 5 days up to 30 or 40. Their outlines are irregular and changeable; some spots are seen to separate, and others to unite, even in the middle of the disk. Besides such minor motions they all have a common motion, with which they all cross the disk of the sun in parallel lines. From this it is learned that the sun is spherical, and that it rotates in about a month in a direction from west to east similar to the direction of motion of the planets. The greater number of spots are found in one particular region or zone, which extends about 28° or 29° from each side of the solar equator. The differences in density and darkness, the changes of figure, and the uniting and separating are evident to the senses and need no further discussion; but whether the spots are adherent to the sun, and whether they are carried around by its motion will need to be reasonably discussed, and will be determined from certain phenomena which have been observed.

The proofs are adduced as follows: First, it is seen that all the spots move with a common and similar movement, although there may be twenty or thirty visible. This is a strong argument for a single cause of motion. This common motion would not be observed if the spots were a number of separate planets revolving around the sun; hence, we must conclude that the spots are in a single sphere which carries them around the sun like the stars (according to Ptolemy), or that they are a part of the sun itself, which carries them with it; of which two conclusions the second appears to be the true one, the other false and impossible. Second, the space over which the spots seem to move from day to day is to be noted. It is observed that the distances traversed in equal times by the same spots are always less when the spots are near to the circumference of the sun, and observing carefully, it is seen that the daily increase or decrease in this motion in equal times corresponds very proportionately to the versedsines and their excesses proportional to equal arcs (molto proporzionamente respondono a i sini versi e loro eccessi congruenti ad archi eguali). This phenomenon could occur in no other motion except circular motion contiguous to the surface of the sun, for should the spots move in circles very far from the sun, the spaces covered in equal times would appear very nearly the same. Third, the changes in the distances between the spots marvelously confirm these conclusions. These distances are small near the edge and increase greatly toward the center of the disk. They are at first very small and almost imperceptible near the circumference, they change with different rates, but always with such changes as could not be met with in any other but the circular motion of divers points variously placed upon the surface of a revolving globe.

Galileo continues discussing these and other proofs, namely, the changes in the appearances of the spots near the edge of the disk resulting from foreshortening, their proximity to the sun, their possible thickness, and the decrease in the darkness of the spots near the edges of the disk; explaining his assertions with the aid of diagrams and geometrical figures, and with a series of drawings of the spots visible between the 2nd of June and the 8th of July. The question is discussed whether the body of the sun rotates and carries the spots with it, or whether the sun is fixed and the spots are carried around it by a sort of fluid envelope. The former conclusion is shown to be the correct one because a medium such as would be required would not be suitable to carry the spots around with it. Further, if the motions of the spots were due to this surrounding medium, it is almost certain that it would communicate the same motion to the solar globe through contact.

Galileo describes at length (to be quoted later) a method of observing the sun and spots without the necessity of looking directly at the sun. This is the method of projection with a telescope, the image being examined on a card or suitable screen. He also states that one can observe without any telescope, the image formed by a small aperture being observed on a far distant screen. He remarks that nature has not limited our facilities for observing, as she has at one time and another produced spots which were large and black enough to be seen with the unaided eye; but a false and venerable belief that the heavens were immutable and incorruptible made men believe that such spots were Mercury interposed between the earth and the sun and that not without shame to the astronomers of that day. Such without doubt was that mentioned in the Annals of the History of France as occurring during the life of Charlemagne, which was described as a spot visible on the sun for eight days. But this was a great error, for Mercury could not remain on the sun longer than eight hours, such is its movement when between the earth and the sun.

Galileo concludes the letter by mentioning that he has received certain observations made at Brussels and at Rome, and that these agree perfectly with his own; proving unquestionably that the spots are far beyond the moon. In a postscript, he states that on the 19, 20, and 21st of the same month a large spot was seen near the center of the sun's disk with the unaided eye, by himself and by many other gentlemen friends. Accompanying the letter are drawings of the sun, showing the spots from June 2 to July 8, and during the three days in August when the large spot was visible.

As Scheiner was unable to read Italian—this he learned during his stay in Rome some years later—he did not become acquainted with the contents of Galileo's letters until Welser had had them translated

for him. But even before Galileo's letters had been written, Apelles sent two additional letters to Welser, dated January 16, and April 14, 1612.

In the first* of these letters, Apelles commences with remarks concerning the supposed transit of Venus and conjectures regarding the failure of its appearance; that the ephemeris of Magini may be in error, etc. The results of his later observations of the spots are; that the spots seldom retain their figure from the time that they first enter the disk until they exit, the spots always appear larger in the middle of the disk and smaller near the circumference, the border of the spots is always rough, and the majority are not as dark at the edge. Round spots are extremely rare, while those with irregular shapes are more numerous. The spots appear like dark snowflakes, pieces of cloth, masses of hair in front of a torch, etc. They all seem to move more quickly in the middle part of the sun than near the edge. All move parallel to the ecliptic. Those that cross near the center of the disk move more slowly than those more distant from it. Two spots are noted, one of which required 16 days to cross near the center of the disk, while another farther from the center required only 14 days, which fact convinces Apelles that the spots cannot be adherent to the sun. The motions and appearances of these two spots are discussed in some detail. The first one was contracted when entering the disk, but expanded in the middle and contracted again at exit. The second is compared to the appearance of Mercury during a supposed transit as observed by Kepler, with the conclusion that the spot is much larger.†

Up to this time there is no evidence that Scheiner had made specific claims for himself as the first discoverer of the solar spots. This, however, he does later in the *Rosa Ursina*. But at the end of the letter of January 16th, he makes something very like a claim, when he remarks to Welser concerning his fears, that if any one should hesitate over the announcement of a discovery, it is possible that others may anticipate him. He writes:‡

> Hence I fear that unless you hasten to be first, these [the spots] will be snatched from my hands, for when the great import of the matter is perceived, the mathematicians will not be able to restrain themselves, but they will hesitate when they consider by how great an interval they follow us, and hence they will either produce their own and proper things, or certainly will not claim that which belongs to others. You alone can prevent this, may Providence bring it about, that, as we have begun this so may we happily carry it forward and finish it.

If this quotation is considered as showing the condition of Scheiner's mind at this time, it would seem to indicate that he was aware that

* *Gal. Op.* 5, 39.

† In this instance Apelles was probably correct in his conclusion.

‡ *Gal. Op.* 5, 54.

someone else had also observed the spots but had neglected to make the proper announcement, and that if the letters were speedily published by Welser he would still be put on record as the first observer. Hence the appeal; but this will be discussed in detail later on.

The second letter* (April 14, 1612) is almost wholly concerned with the account of the discovery and observation of a supposed fifth satellite of Jupiter on March 30, 1612, and which Scheiner subsequently dedicated to his patron Welser. It is of interest to note that Winnecke† has shown that there was no error in the observations of Scheiner, but he had unknowingly observed a variable star.

*(To be continued.)*

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## NICOLAUS COPERNICUS.

### CHARLES NEVERS HOLMES.

Ptolemy's idea of a stationary earth and a moving Universe had survived for centuries longer than it should have, and in Nicolaus Copernicus we find the man who completely shattered Ptolemy's idea. More than 2000 years before, the famous Pythagoras had believed in a moving earth and a central sun, but the naturalness and simplicity of this belief had been overwhelmed by the arguments of Ptolemy. The Ptolemaic System had a firm and traditional hold on the minds of men, and at first the doctrine of Copernicus was rejected or coldly received. But although it may take generations and generations of time for a great error to be corrected, nevertheless truth in science as well as in other important matters will ultimately be triumphant.

Nicolaus Copernicus was born at Thorn in Poland, on February 19, 1473. His father was a Pole, his mother a German. His family did not belong to the nobility, in fact his father was a tradesman. Very little is known respecting the youth of this future great astronomer. He was educated at home, then sent to the University of Cracow, where despite the incompleteness of his educational equipment, Copernicus studied diligently, particularly medicine, theology, mathematics and astronomy. In 1496, in his 23rd year, he went to Italy, residing two

* *Gal. Op.* **5**, 54.

† *Vierteljahrsschrift der Astronomischen Gesellschaft*, **13**, 283.

years at Bologna where he studied canon law and astronomy. At Cracow it had been his intention to be a doctor; but by the advice of his uncle, Bishop of Ermland, he gave up this profession and prepared himself to take holy orders, being appointed in 1497, while yet in Italy, a canon of the Cathedral of Frauenburg.

In 1500 Copernicus visited Rome where he lectured on astronomy, for his mathematical mind had induced him to choose that science for a profession. In 1501 his uncle, Bishop of Ermland, died, and about that time he settled permanently in Frauenburg, although he lived afterwards for some years at Heilsberg. At Frauenburg he combined a number of offices and duties, such as military governor, bailiff, judge, tax-collector, vicar-general and physician. Copernicus was appointed administrator-general of the diocese of Ermland in 1517. He seems to have led a very laborious and industrious life at Frauenburg, with his theological duties, attending the poor medically, and his researches in astronomy and mathematics. But his chief interest must have been in his great work, "De Revolutionibus Orbium Coelestium," a book in six volumes, whose arguments shattered finally the Ptolemaic System. Although his astronomical labors occurred centuries after the time of Ptolemy, astronomy was yet in its infancy, and all the work of Copernicus was accomplished before the invention of the telescope (1610).

The belief of Pythagoras appealed to Copernicus, as it seemed more natural and more reasonable that our earth should revolve around the sun than that the opposite should be true. He began to look into the matter carefully and became more and more convinced that the theory of Ptolemy was utterly erroneous. The daily rotation of our earth on its axis, explained by Ptolemy as due to the movement of a vast crystalline sphere in which the distant suns were fixed, seemed to Copernicus far more simple and sensible. Copernicus admitted that this apparent motion of the sun and suns was caused either by the sun and distant suns revolving around our earth or by motions of the earth itself. Ptolemy had denied utterly any motion of our earth; but Copernicus came to the conclusion that this apparent motion was the result of a movement of our world.

Copernicus argued that people on board ship moving through quiet water, would think the vessel at rest while houses and trees on shore seemed to be in motion. This was the same illusion that had deceived those who believed in the theory of Ptolemy. Not being able to perceive our own terrestrial motion, we might imagine that the sun and distant stars were revolving around us whereas their apparent movement was wholly caused by the rotation of our earth. Ptolemy had declared that were the earth to rotate, the air would not rotate with it, and the world would not be habitable, owing to the terrific wind

rising from the velocity of the earth as it revolved rushing through the air. To this Copernicus replied that the atmosphere would accompany the rotation of the earth, exactly as one's coat accompanies him, whether he is standing or walking.

Ptolemy had asserted that all the distant stars were attached to the surface of the celestial sphere, each star being at exactly the same distance from the world. Copernicus declared that this so-called celestial sphere could not really have a material existence, for such a conception was not natural and it was not necessary that every star should be placed at exactly the same distance from our earth. There was no good reason why these stars should be so fixed and the whole theory of such a crystalline sphere seemed very unnatural, Also, there was a question of what sort of substance composed this sphere as well as the problem of its thickness and whether or not something did not lie back of it, on the other side. In fact, such a sphere was too complicated and wholly unnecessary. How much more simple and how perfectly natural to believe that our earth revolved around the sun just like Mars and the other planets.

Thus Nicolaus Copernicus carefully thought out his celebrated Copernican Theory; and, studied from the standpoint of past centuries and modern science, it is evident that this theory is true. In fact it has hardly any need of argument, particularly in the light of 20th century astronomical research. But although Copernicus gave us this immortal Theory, although he explained certain other things about Mars and the planets, he could not exactly understand regarding their orbits around the sun, and this astronomical work was left for the great Kepler.

Copernicus was well known at the time not only as an astronomer but also as a mathematician. He wrote a treatise on trigonometry in 1542; and he also made a translation in 1509 of the epistle of the Byzantine writer Simocatta.

But although Copernicus completed his "De Revolutionibus Orbium Coelestium" in 1530, it was not given to the press until some 13 years afterwards. He hesitated for a long while about giving his work to the world, because of the opposition and controversy that it would arouse. At last his friends became so insistent that he decided to publish it, but before it appeared Copernicus was taken mortally ill. On May 23, 1543 a copy of the book was brought to him, but he died a short time afterwards. "De Revolutionibus" was, therefore, first published in 1543, at Nuremberg; but there were later editions at Basel (1566), Amsterdam (1617), Warsaw (1851), and at Berlin (1873).

Thus, lived and died Nicolaus Copernicus, who rescued our world rom the error of the Ptolemaic System. A good, learned, industrious

man; a remarkable and valuable career. Astronomy saw its first real dawn in him, with all honor to those who groped in the darkness of science before him. The error or the truth about a great fact does not change the reality of that fact; but man wants to know the truth rather than the error about astronomical science, and therefore our world owes a deep debt to Nicolaus Copernicus of Frauenburg.

Hotel Nottingham,
Boston, Mass.

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## THE DISTRIBUTION OF GASEOUS MATTER THROUGHOUT INTERSTELLAR OR COSMIC SPACE.

THEODORE WILLIAM SCHAEFER, M. D.

It has been supposed for a long time that the space that separates us from the sun is a desolate void not containing any air or other known substances of a gaseous like nature, except the mythical something or hypothetical medium called the ether, by means of which energy is transmitted in form of undulations through space. In a similar manner it has been supposed for a long time that this same immensity of space is at absolute zero temperature, having so been affirmed with an evident assurance of certainty and supported by a plausible display of mathematical calculations. The first supposition has just been successfully assailed by a few eminent scientists and there appears to be a gradual natural philosophical regression with respect to this conception which was firmly believed until recently. The second supposition, however, that of the assumed absolute zero temperature of space, has not been courageously attacked by men of science. It still flourishes in scientific works as a pet, traditional, scientific fiction.

### Ancient and Modern Views of Our Atmosphere and Heavenly Space.

In antiquity, when it was assumed that the earth stood still in the center of the world, the ancients concerned themselves but little about the limits of the terrestrial atmosphere. The region of the clouds, lightning and meteors was considered the upper boundary of the atmosphere.

Anaximenes of Milet and Diogenes of Apollonia, who lived in the fifth century before Christ, placed the primordial matter of all things in the air. A distinction was made even in antiquity between the air and the ether (Aristoteles). During those times it was not perfectly clear whether the ether possessed the all-penetrating importance that is given to it to-day in our physical theories or whether the ether, unlike the air, was to be considered the essential material medium filling the heavenly space beyond the highest strata of the air. This uncertainty, however, of the limitations of the atmosphere vanished as soon as a rotary movement of the earth and subsequently a revolution around the sun became known.

According to the nebular hypothesis of Kant and Laplace the whole interstellar or cosmic space was originally filled with gaseous matter, including air.

## The Hitherto Prevailing Ideas of the Height of the Atmosphere of the Earth and the Material Conditions of the Cosmic Space.

The atmospheric envelope surrounds the solid body of the earth in the form of a hollow spheroid. Its height has been calculated from the instant that meteors flash and after the disappearance of the blue color of the sky when twilight is approaching and after other signs, to be approximately from 200 to 250 kilometers. Of course, these figures are only of relative value and for the time being. But beyond and further into space rarefied gases fill the space between the planets and the sun: Gases which we have designated in antithesis to the atmosphere of the earth as the atmosphere of the heavens and which are clearly to be differentiated from the ether, that assumed medium, which is supposed to fill all intermolecular space of ponderable matter and which transmits the electrical, heat and light phenomena. While the atmosphere of the earth still participates in the movements of the earth, there are other and more distant strata of the air that no longer or not so completely take part in the rotation of the earth, *i. e.*, remaining relatively quiescent, but are, nevertheless, carried along in the moments of the earth around the sun and then further on as the earth, including the whole planetary system, wanders through the world of space.

A numerical limit between the heavenly atmosphere and the atmosphere of the earth has not been estimated, says Supan,* but from the observations of the "silvery clouds" (Jesse's night clouds) we know

* Grundzüge der Physischen Erdkunde von Prof. Dr. Alexander Supan, 1908, p. 50.

that already at a height of 82 kilometers the strata of air are no longer in full dependence on the rotation of the earth.

From certain perturbations or so-called movements of resistance observed in cometary formations in the inner space which is in proximity to the sun, we infer the presence of ponderous cosmic matter, gaseous and ultra gaseous elements, besides the universal ether. If our cosmic space were filled exclusively with the universal ether we should not anticipate any perceptible resistance offered to the movements of the earth. Inhibitory effects, however, have been noticed in the movements of swarms of fine particles of cosmic matter out of which certain cometary forms are composed. This resistance has been clearly proven to be the case in a striking resistance with Encke's comet. There is a constant presence of material elements of a coarser kind existing in the space surrounding the sun between the planetary paths. In short, it can now be maintained with great certainty that the space of our planetary system is not only filled with the ideal medium called the ether, but also with small and very minute elementary masses of a solid or gaseous nature, and, furthermore, probably a part of these material elements describe a planetary movement around the sun, whereby the resisting action of this part that fills the space against the movements of the planets is naturally diminished. On the other hand, another part of the material elements, essentially under the influence of the power of the attraction of the sun, attracted by the latter from their cometary paths of the outer planetary space, wander through our system and at the same time cross the paths of different planets, and finally penetrate very often their very atmospheres as well as the atmosphere of our earth.

It is evident that in such a manner cosmic matter, of a solid nature, containing occluded gaseous matter, enters our atmosphere with great velocity and often in a state of incandescence. The whole problem of the conditions of the highest strata of the atmosphere becomes indeed important if we conceive of a space filled with cosmic dust, gaseous and ultra gaseous matter. It is indeed conceivable that traces of counter actions occur in the highest strata of the air, where very complicated and peculiar movements must obtain. We refer to the illuminated trail of meteors or shooting stars, luminous clouds, etc., that leave a lighted path along their passage. To all these phenomena we have first of all no other choice than the assumption of counter actions of a cosmically filled space through which the earth, in its path around the sun, is moving with the enormous velocity of 30,000 meters per second.*

* Von der Erdatmosphäre zum Himmelsraum. Von Professor Dr. Wilhelm Foerster, 1906, pp. 9-24.

Arrhenius* has calculated the amount of matter that falls upon the earth from cosmic space to be about 200 tons a year. The action of this dust is, nevertheless, considerable on account of its fine attenuation and it should constitute a far larger amount in the higher strata of the air than is furnished by the downfall of meteors or falling stars. These particles of matter carry off gases from the sun which are capable of condensing on their surface, which existed originally in the chromosphere and corona of the sun. Particles of dust take up the rays of the sun and give their heat to the individual molecules with which they collide. Ionized gases possess the remarkable property of condensing vapors. Wilson has shown that the negative ions possess this property to a higher degree than the positive ions (by condensation of watery vapor). If, therefore, vapors in the vicinity of the sun, which become cooled, and condensed, the formed drops of water will be precipitated at first upon the negative ions. When the vapors are driven away by "radiation pressure" (Arrhenius) or fall down in consequence of gravity, like the rain drops in the atmosphere of the earth, they therefore carry the charge of negative electricity, while the corresponding positive electricity remains in the gas (respectively the air). In this way the negative and positive charges are separated from one another and electrical charges may be the result if sufficiently large quantities of electricity are separated from one another. In consequence of these discharges which pass through the gases the latter become luminous, although their temperature may be apparently very low. It is probably worth mentioning that the strongest spectral line of the Northern Light (Aurora Borealis) has been found to belong to the noble gas krypton. As this gas occurs but in minute traces in the atmosphere, it is not improbable that it is carried with the solar dust (occluded) and that its spectrum, therefore, appears on its electrical discharge. Recent investigations make it probable that the noble gases discovered by Ramsay, which are similar to argon, neon and xenon, and which have not yet been separated from the nitrogen spectrum, likewise take part in the formation of the spectrum of the Northern Light. Krypton,† found in the infinitesimal proportion of one to twenty millions, glimmers in the Northern Light. Of special importance is neon's transmission for electrical light. Air requires 1,000 volts, neon requires but thirteen volts. The blue color is absent in the spectrum of neon, its coloring being somewhat *red.* Indeed, some very interesting experimental researches of Birkeland, published in the *Scientific American* Supplement, July 5

* Das Werden der Welten. Von Svante Arrhenius, 1907, pp. 4-189.

† Erdmagnetismus, Erdstrom und Polarlicht. Von Dr. A. Nippoldt, Jr. 1903, p. 120.

and 12, 1913, on the Aurora Borealis, render it probable that the phenomena is due to corpuscular radiation proceeding from the sun to earth. Among other things, gases can be ionized by being charged with Röntgen rays, cathode rays or ultra violet light as well as being strongly heated. As the rays of the sun contain much ultra violet light, it is undoubted that the masses of gas in the vicinity of the sun (perchance in the case of comets that come near the sun) are partially ionized and contain positive as well as negative electricity.

## Gases are Continually Leaving the Atmosphere of the Earth as Well as Other Celestial Bodies and Escape into the Great Cosmic Space.

The kinetic theory of gases gives a simple explanation for a number of highly interesting observations which concern the gaseous atmosphere of the heavenly bodies. The hypothesis evolved by the eminent Dublin scientist Dr. Johnstone Stoney,* contains a considerable element of truth. It is simply this: Gases are continually leaving our atmosphere, owing to the intrinsic rate of motion of their molecules. For example, when a molecule of hydrogen arrives at the confines of our atmosphere it may escape, provided its rate of motion is sufficiently rapid. And it may be proven that some molecules of hydrogen possess sufficient velocity to carry them beyond the sphere of the earth's attraction. If given ample time, all molecules of hydrogen would ultimately fly off and would find a home when they reached a body of sufficient mass, and, therefore, of adequate attractive force to retain them permanently. The sun is such a body; and it has been abundantly proven that free hydrogen exists in quantity in the solar atmosphere.† The chief objections to Stoney's deductions have been logically removed. Among the gases hydrogen and after this helium and other noble gases, including those of an ultra gaseous nature, play the chief role. Some of these gases occur, though in small quantities, in the atmosphere of the earth, others occur in nebulous masses and larger celestial bodies. As far as hydrogen is concerned, Sieveking and Mitchell maintain that it is not generated in the atmosphere of the earth. From the kinetic theory of gases the inference is drawn that isolated molecules of gas must constantly leave the atmospheres of planets, as soon as their velocity should accidentally become so great

* Johnstone Stoney, *Astrophysical Journal* **7**, 25 (1898); **9**, 1 (1899) **11**, 251-357 (1900); *Nature* **61**, 515, (1899).

† The Gases of the Atmosphere, The History of their Discovery, By Sir William Ramsay, K. C. B., F. R. S., 1905, pp. 265,266.

that they overcome their attraction. Stoney has drawn attention to the fact that a body that is moving upward from the earth with a velocity of 11.2 kilometers per second would no longer be held back by the gravitational force of the earth, but would fly off into infinity, apart from the consideration of the attraction of the sun. According to the laws of probability there must be some also among the molecules of a gas that have attained the necessary velocity, and, conversely, there are some which are not sufficiently swift, to abandon even the smallest heavenly body. No planet can (in empty space) possess theoretically an absolutely permanent atmosphere, and none can have lost it completely. When the number of molecules with sufficient momentum has become very small, then the atmosphere can be actually considered as nearly permanent. For those gases that have a low specific gravity and therefore a greater average velocity (the density of oxygen O is 16 to hydrogen H, the average distance of the path of the molecule H is therefore four times greater) the probability is greater, that single molecules attain accidentally the extraordinary speed that is essential for abandoning the atmosphere. Of this kind of gases more escape than from the denser ones. This process will remove in the course of time all gases from the atmosphere of planets of definite mass and force of attraction, whose density is below a certain limit. The velocity that is essential to leave the earth must be five times greater than the one necessary to leave the moon, as the potential of the earth is 25 times greater than that of the moon. For this reason the moon can possess but a barely perceptible atmosphere, as even the lightest gases, like hydrogen and helium, have wholly or nearly wholly escaped from the atmosphere of the earth.* The often repeated contention, so ably advanced by Friedel, Foerster, Birkeland and others, that the interstellar space is supposed to be filled with fine cosmic dust, representing many elements, seems, therefore, to be of far reaching importance. Birkeland, however, believes that the interstellar space is airless. That originally corpuscular matter in the form of supposed electrons, possessing great penetrative and accumulative powers, should have for ages filled cosmic space, is, indeed, not a new idea. Theoretically, Foerster, Stoney, Friedel† and others have for a number of years advanced this supposition. Birkeland, starting with experimental analogues, has studied practically the action of electrical discharges in "vacuum chambers," which he compares with cosmic phenomena like the zodiacal light, etc., which seems to be of great importance in understanding solar phenomena and the evolution of all celestial bodies of the universe.

* Lehrbuch der Meteorologie von Dr. Julius Hann, 1906, p. 2-3.

† Johann Friedel, Petermann's Mittheilungen, 1905, p. 43.

From these different points of departure of the reflection of the limitation of the atmosphere of the earth we logically come to the conclusion that there is actually no real limit of our atmosphere and that beyond the atmosphere cosmic space must be filled with gases which are exceedingly rarified.

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## MARS AND ITS MARKINGS.

HARRY HUSSEY.

Having followed the sea as a profession for many years and for as many years having worked in astronomical observatories I have been much struck by the similarity of the conditions governing the seeing or observing, both in an observatory and on board ship. When I left the sea I had attained the rank of second officer of a tea clipper, and though working in a subordinate capacity in observatories, yet I have had innumerable opportunities for observing and can speak as one having some knowledge of the subject.

Sailors are merely ordinary men specially trained, and other things being equal, their eyes are in no way superior to those of landsmen, that is, as eyes; but owing to long practice they can with ease pick up an object at sea that is invisible to a passenger. This I have noticed more times than I can remember, not only on board ship but also in an observatory, for the same rule holds good in both places. One observer can see easily planetary detail that is invisible to another who has had less experience, just as the sailor can see that which is invisible to the passenger.

What would be thought of a passenger who when a distant vessel had been pointed out to him by a sailor, he had replied, "There is no ship there, how can there be when I can't see it, and I have good eyesight." What could one say of such an one?

Yet, when I went to work in an observatory I found, to my great astonishment, that there were men of little or no experience in observing planetary detail (passengers) who denied the existence of markings that were easily visible to observers of long experience (sailors).

I am not a skilful observer, yet I have seen with ease and distinctness the more prominent of the "canals" of Mars, not only with the 24″ of the Lowell Observatory but also with the 60″ mirror of the Mount Wilson Solar Observatory, and I have drawings made from observations with both instruments.

The conditions for observing at Mount Wilson were not good, we had to hold the eye-piece in our hand and rest the arm on the telescope, nevertheless I could see "canals" which are shown on the drawings I made there.

During the three years I was at Mount Wilson, the 60″ mirror was turned on Mars twice for visual observations, one of the times the seeing was 8 on a scale 10 (10 being the best) for steadiness, but with a fine blurring over the surface of the planet, the other time the seeing was not so good, and to me the definition of the big mirror did not seem nearly as good as the Lowell 24″, but, of course, one could not say that with certainty after only two short tests, also taking into consideration the mechanical difficulties one had to contend with at the eye-piece.

There is one thing I have run across in my observatory experience, which I have never met at sea, and it seems hard to believe, but I have seen it shown so plainly and often that I *must* believe it; it is this, there are not only those who from lack of experience are unable to see "canals" or even well-known markings, but there are others who do not want to see them and won't see them, and, of course, "There are none so blind as those who won't see"'

What their motives are I cannot conceive, but that there are such men is a fact for I have both seen and heard them.

One such man I remember distinctly whose point of view was this, "Oh, what's the use of looking, there are no canals, its all foolishness, anyhow." Now this, I would hardly call an unbiased or unprejudiced state of mind in which to approach the subject, yet he is not alone in his way of looking at it, I have met others: but it is a two-edged weapon, for I have known people who could not see the Fastigium Aryn, a well-known marking which the above mentioned man *could* see, yet by following his own method of reasoning (if one may call it reasoning) these people could say he was mistaken, how could there be such a marking when they were unable to see it?

I can recall the sorrow and astonishment I felt when I ran across this kind of thing first. Astronomy I had always known to be the noblest of all sciences, and by inference I had thought astronomers to be the noblest of men, far removed from all the petty meanness of common humanity.

Of course, no one can expect to see fine (I was going to say faint, but it is by no means faint with good seeing) planetary detail if he only looks occasionally and casually at the planet, any more than a young seaman can become a trustworthy lookout man if he keeps his eyes on the deck all the time.

Yet I have found very clever men, after only three or four casual observations of Mars, under very indifferent conditions both mechanical and atmospheric, who would make positive statements as to the existence or non-existence of planetary markings.

I have just experienced a good illustration, both of the value of good seeing and of practice.

Last week I looked at Mars for the first time since I left Mount Wilson six years ago. Mr. Slipher was observing and had just seen the Propontis, he asked me to look and see if I could see it: he told me where to look for it, but I could not see it, in fact I could see only a confused and blurred mass of faint markings; which to Mr. Slipher's practiced eye, were by no means confused or blurred. There being no one ready to observe, I stayed at the eye-piece idly watching the planet, and the seeing became better and better until there gradually came one of those periods of superlative seeing for which this Observatory is famous (I believe it was located here for that reason) and not only the Propontis but every marking on the planet as plain to be seen as if it was a photograph or a printed map. It was mighty interesting and I don't care how blasé or uninterested a man is, such an experience will cause him to exclaim with joyful amazement.

When I speak of the image being confused or blurred I do not mean the planet as a whole; that is, the planet may be perfectly still with a sharp cut rim, and yet there will be a fine blurring all over the surface: an inexperienced observer would call that kind of seeing very good and for most kinds of astronomical work it would be good, but for seeing or photographing fine detail it would not be good.

What a revelation these periods of perfect seeing would be to some of the doubting Thomases I have met! I am very certain even they would be unable to repress the exclamation of amazement which every man utters when the perfect image first comes into view before him, though I have met one man, who I am very sure would shut his eyes when the perfect seeing came, and I suppose there are others.

Whether it is owing to the configuration of the surrounding country (which is unique) or the altitude or the geographical position or a combination of all three, I do not know, but here at the Lowell Observatory there are certainly periods, during a night of good seeing, when the seeing is perfection, and adding to this a flawless objective one should not be surprised at the results obtained by the observers here.

But I have wandered away from my subject, which was to point out the similarity of the conditions both on board ship and in an observatory in regard to seeing faint objects. To my mind, the analogy is complete, even to the cry of joy which I have heard many times both

from passengers on ship-board and observers at a telescope when they first see an object which up to then had been invisible to them (though visible to experienced men) and which they almost or quite doubted was there.

January 28, 1916.

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## SOME INTERESTING ASPECTS OF THE SIDEREAL UNIVERSE.

HENRY HANDY McHENRY.

There is nothing that impresses one so completely with his own insignificance as the contemplation of the wonders of the sidereal universe. The egotism of even the most famous of mankind must surely vanish when he views those vast worlds hurtling their way thru the limitless voids of space. It is noteworthy that all men who come closely in touch with nature are modest and unpretentious, so long as their researches are conducted in the simple spirit of learning the truth for its own sake. It is only when actuated by worldly motives of greed and desire for fame that they lose that splendid humility which characterizes the sincere scientist when in the presence of the sublime wonders of the infinite cosmos.

Viewed from the physical standpoint of our earthly experience even the grand total of human achievement since the advent of Man is as nothing compared to the mighty forces at play, creating, remolding and destroying worlds millions of times the size of our sun, with never a moment's rest. John Burroughs has written at length on the marvels of the infinitesimal world of atoms and electrons whose ceaseless eruptions are ever with us though too minute to be perceived by the most powerful microscopes. This is, indeed, a wonderful world to contemplate, but it seems to me that the conceptions of the infinitely big, encountered in Astronomy, are even more magnificent.

I will name some of the facts disclosed to us in the great field of Astronomical Science of which we can only form a dim idea. To attempt to truly picture them is beyond the scope of the human imagination. Even the great minds who discovered the laws of planetary motion and sidereal velocities have confessed themselves incapable of appreciating the full magnitude of their works.

The marvels of our own solar system are not to be overlooked. But sublime as the phenomena of the planets are, they pale to the commonplace when compared with the infinitely staggering facts of the sidereal universe as a whole.

Although light travels at the rate of 186,000 miles a second it takes nearly four years for the light to reach us from the nearest star, Alpha Centauri in the Southern Cross. In fact the parallax or vertical angle, from which the distance is computed, of only about one hundred and twenty five stars has been even approximately determined. Using the greatest diameter of the earth's orbit as the base of the triangle, and the star as the apex, the greatest parallax known is only three-fourths of a second of arc! It is probable that the stars in the Milky Way are from seven hundred to a thousand "light years" away, and as the power of stellar photography has increased, more remote stars are continually revealed. Just think of it! Many of these stars we see not as they existed in our own time or even in that of our forefathers, but as they were before man lived on earth! Perhaps there are some that the people of this world will never see.

Undoubtedly many of the stars we see today have burned up hundreds of years ago and are merely cold, dark bodies tossing helplessly about in space. When a star first begins to condense from a gaseous nebula, it is blue in color. As contraction continues it becomes yellow, which at old age merges into red. Following that the star soon loses its light and heat. I say 'soon.' The life of a star is only a matter of a few hundreds of millions of years. Green stars such as Castor, or orange like Albireo, at the foot of the Northern cross, obtain their color from chemical elements which they contain, existing in a highly incandescent state.

The sun is now in the yellow or middle aged state. When it burns out, the earth will have become too cold to support life, at least as we know it. Science has calculated that the sun grows about a degree cooler each day.

The heat of these stupendous bodies is inconceivable as well as their size. The star Altair radiates ninety times as much heat as the sun. Rigel in Orion, is so far away that its distance has never been even approximately calculated, but its brightness indicates it to be a tremendous reservoir of heat. Arcturus is more than two hundred times as large as the sun.

We are accustomed to refer to the stars as 'fixed', but as a matter of fact nothing is less immovable. Every star is travelling thru space at a tremendous velocity. The greatest stellar velocity known is that of a star in the constellation of Cygnus which loiters along at the rate of five hundred miles per second. Our own sun with its attendent planets

is rushing toward a point in Hercules at eighteen miles a second. When we get there the stars in that vicinity now will be hurrying thru some other part of the universe. Inside of a few million years the Big Dipper, Orion and other celestial landmarks will have ceased to exist. We shall have to find a new Polaris to guide our ships by. Arcturus, which has a greater velocity than any other first magnitude star, is said to have moved a little more than a degree since the evening it attracted Job's attention.

Undoubtedly collisions have occurred between these cosmic cannon balls. The sudden appearance for a brief period of a bright star hitherto unknown, and the equally sudden disappearance of an old celestial friend leads astronomers to believe that stars occasionally collide with each other, especially the myriads of invisible, burnt out bodies that glide thru space like mysterious gigantic monsters. What an inconceivable cataclysm must take place! A terrible rending of worlds, a breaking up of vast continents into a conglomerate mass of molten matter, and fire, far surpassing the most terrible earthquakes and conflagrations we have recorded in history!

The impossibility of life existing as we know it on the planets, has been generally established—even for Mars. But one must not forget that in all probability millions of the stars are, like the sun, the centers of an invisible retinue of planets and satellites, perhaps even more vast and complex than our own solar system. Surely it is not likely that our planet is the only one in the whole cosmic universe capable of supporting human life. There may be planets where races of human beings live whose civilization surpasses ours by an even greater margin than we have advanced beyond the ignorance of primitive man, to say nothing of the possibility of life existing of a totally different nature. Bergson has declared that the chemical affinity of the carbon, oxygen and hydrogen atoms is the genesis of all biological species. May there not be worlds where other elements unite to create species of an entirely different type?

We well know the utter futility of attempting to form an accurate mental conception of the minute atoms and electrons of which matter is composed. But, seeing the futility of grasping that which science has proven, may there not, by analogy, be an infinitely greater *universe* than we have as yet suspected? The people in such a universe would regard the stars and their attendant planets as we regard the positive atomic nucleus and its attendant negative electrons. They would be infinitesimal—invisible save in the minds of these Brobdingnagian scientists. The possibility of such a super-cosmos seems to me to be the most appalling conception the human mind can venture to create.

The achievements of the masters of astronomy whose lifelong labors have given us the key to the secrets of the universe cannot be praised too highly. They have contributed not a little thru the enlightenment shed broadcast to the advance of civilization. The miracles attained in perfecting the telescope, the development of stellar photography, and the valuable discoveries made possible thru the spectroscope—to say nothing of the infinitely abstruse mathematics required to compute even the simplest planetary and lunar tables, are immortal monuments to the ingenuity of mankind. We are far too inclined to pass over these purely mechanical aspects of astronomy, yet they are the tools without which we would have been as ignorant of the laws governing the universe as our ancestors were in the Dark Ages. The names of Galileo, Brahe, Kepler, and the Herschels will live forever among the great servants of humanity. Nor must we forget the modern astronomers such as Adams, Le Verrier, Pickering, Hale, Campbell, Frost, Moulton, Barnard, Larkin, and Chase, whose work has been of noteworthy value.

But let us turn from the sublime to dwell awhile on the aesthetic nature of the celestial vault. We feel a certain intrinsic loneliness while beholding these peerless jewels, of a distinctly individual character. I doubt if the sentiments of the lover of lake, mountain, or floral beauty are equal to those of the ardent star gazer. To one acquainted with the geography of the heavens, the first magnitude stars and the more impressive constellations assume the rôle of old friends. What a sense of security and comradeship it must give the sturdy arctic explorer when his way across the frozen wastes is brightened by the familiar rays of Vega or Capella! It is akin to the light that guided Leander when he swam the Hellespont.

What pleasant memories are recalled by Orion's splendid array gleaming far above the restless metropolis on a wintry night of that wonderful sail we had last summer when we glided lazily thru the quiet phosphorescent waves until when dazzled by the advent of Sirius above the eastern horizon we were reminded that it was well nigh unto daylight. Truly to him who has sensed the infinite charm of the celestial host belongs untold riches—treasures not to be envied because others fail to appreciate the subtle significance which lends them a rare tone.

The stars have always possessed a certain sense of mystery—their effect on some people is almost hypnotic. One sometimes feels as if his deeds are diurnally weighed by those strange nocturnal eyes, seeming to pierce the shadows of the soul itself. The imaginations of the Ancient Greeks were lured into building up impossible resemblance to bird, beast, and fish from the configurations of the stars. Most of the constellations still retain these ancient names, though there are some

new ones such as The Sextant and The Clock. While the outline of The Hunter, The Sickle, and The Northern Crown are apparent to all, it takes a stretch of the imagination to discover The Lizard, The Swan, or The Horse. Likewise we find that superstition has attached itself to the stars with greater tenacity than to almost anything else. Astrology once held the place of the most dignified of sciences, and its teachers were revered as the greatest intellects of their time. Even now there are people whose superstitious natures cause them to still cling to this obsolete necromancy. Today there exists a College of Astrology in Portland, Oregon!

The mystery of the Pleiades is still as impalpable as it ever was. There they lie, seven sapphire gems embedded in a nebulous veil. Countless legends have been wrought around them. At one time it was declared that the Pleiades were the fixed center of the entire universe which revolved around it in cycles of seven hundred years. The mystic number 'seven' is significant here. Neither can we forget the fabled "music of the spheres." Each heavenly body was said to give forth an individual vibration, and all in motion simultaneously produced a harmonious music which magicians and seers declared they sometimes heard.

Symbolism abounds in the heavens for one who is prone to indulge in such fancies. Fomalhaut, the Lonely One, that prominent first magnitude beacon in a comparatively starless void in the south, gives the impression of a great mind far in advance of his contemporaries, such as Buddha, Christ, or Newton. The fiery Antares and his brilliant retinue constantly remind one of the Lord of The Mailed Fist, while the Great Nebula of Andromeda seems to represent the genesis of the work of future generations, as yet uncrystallized from the realms of abstract thought.

For the happy star gazer who can afford even an inexpensive telescope a whole world of new wonders is revealed. The sky appears to be suddenly populated by millions of newcomers. We can examine at leisure many magnificent multiple systems—two or three stars constantly revolving about each other. Sometimes one of these is a dark body causing variability of brightness, like Algol which changes from second to fourth magnitude every four days. The splendors of many exquisite nebula are laid before us such as the Ring Nebula in Lyra, and the beauty of those in Andromeda and Orion are increased a hundred fold.

In urging a popular education in astronomy one might remark that our children would never be homesick if they learned to recognize the heavenly host that still watches over the familiar home scenes. But

seriously speaking, I think that astronomy should be included in every high school curriculm. Not the mathematical side, of course, as that is too technical and uninteresting for most people, but a thorough knowledge of the fuhdamental facts of physical astronomy. In these practical days education has been largely transformed from mere book learning into a means of preparation for our careers. Nevertheless a very proper reaction has set in, and it is becoming more and more apparent that it is desirable for every student to carry several purely cultural studies.

Certainly astronomy should be included among this group. It is only reasonable to require that every well-informed person should possess an elementary knowledge of our solar system besides at least a bowing acquaintance with the geography of the heavens. As I have hinted above, even an imperfect conception of the great cosmic forces at work in the universe helps one not to over-emphasize the importance of his own Ego, and instilled in the minds of the young would constitute a potent influence against the exaggerated materialism of the present time.

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## VENUS IN THE WEST.

The gloaming lingers and yon western sky
Is darkly blue—another night draws nigh;
A wintry shroud lies white o'er vale and hill,
The frosty air grows colder—all is still,
A crescent moon sets wanly, then afar,
Serene, resplendent, shines an ev'ning star!
Amid the dark, supernal dome of night
It hangs like mirror of celestial light,
And pearly white above a knoll's black crest
Once more is Venus regnant in the west.

CHARLES NEVERS HOLMES

Newton, Mass.
41 Arlington st.

## REPORT ON MARS, No. 15.

WILLIAM H. PICKERING.

In has occurred to the writer that there may be some persons interested in Mars who would like to make useful observations of the planet, but who do not know precisely how to begin. It is proposed therefore to devote a few pages of this report to a description of the proper use of the Ephemeris, as published in the Nautical Almanac. It is possible also that even some regular observers may find a suggestion here and there that may be of use to them. A very elementary knowledge of trigonometry is necessary in laying out the proper angles, and will be assumed. What is stated here applies directly to the *American Nautical Almanac*, but it applies nearly as well to the *British*, the main difference between the two being that a few of the quantities given in the former are omitted in the latter, and that the headings of some of the columns differ. We shall illustrate our remarks with a practical example, assuming the observation to be made on the evening of April 10, 1916, for an observer using Eastern Standard Time.

The *American Ephemeris* is computed for Greenwich Mean Noon, which for this observer occurred April 10 at 7 A. M., or as the astronomer records it on April 9, $19^h$. It would be much more convenient for everyone if the ephemeris were computed for Greenwich Midnight, or 7 P. M., April 10, and it is hoped that this change may be made in the near future, as was done some years ago by the *British Nautical Almanac*. It is very desirable in making drawings of Mars to have a disk properly outlined on paper, the gibbous shape being correctly shown, and the positions of the poles marked, before any attempt at sketching the details is made.

We shall assume the scale of the drawing to be three millimeters or one-eighth of an inch to $1''$. It is unfortunate as shown in our Report No. 10, that the angular diameter of Mars as given in the Ephemeris is appreciably too large. We understand it will be changed before long, and we hope back to the correct value until recently given in the *British Nautical Almanac*. We shall assume that our drawing will

be made at about seven o'clock in the evening. This will be $12^h$ after Greenwich Noon. The diameter given for April 10 is 10″.10 and for April 12, 9″.93. Interpolating for $12^h$ gives us the diameter 10″.06. To correct the error in the Ephemeris, we divide by 13.6 and subtract the quotient from 10″.06, which gives us the true diameter of Mars at that time as 9″.32 We accordingly draw one or more circles having diameters of three times this, or 28.0 millimeters.

On account of cloudy weather the drawing may not be made on the date for which the outline has been drawn, but the changes occurring in a day or two are of little moment. For this reason in drawing the preliminary outline it is not really necessary to interpolate, although this is done in the description in order that it should be theoretically correct. In the computation of all quantities determined after the drawing is completed however interpolation should be used.

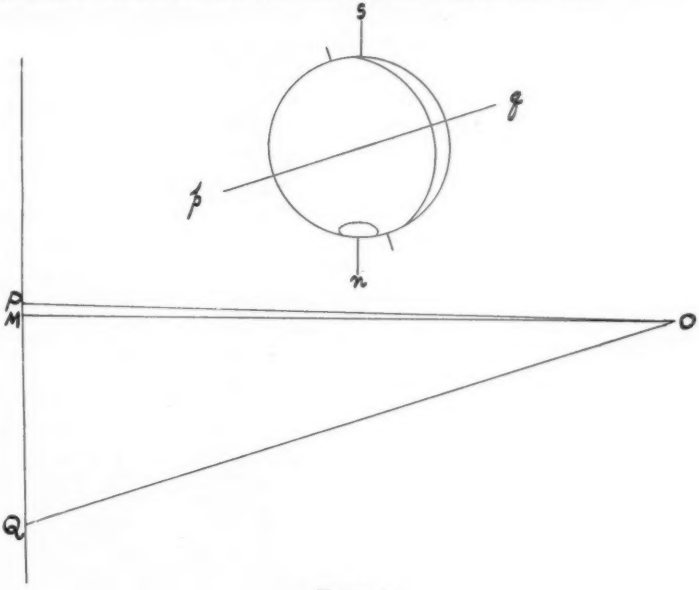



FIGURE 1.

It is the custom of the writer to enter all his drawings on the right hand page of a record book, which is ruled in horizontal lines, with a vertical line at the left hand side. The drawing is centered on one of the horizontal lines and the circle drawn. On one of the lines beneath it, we lay off a distance of 100 millimeters, from the vertical line to the point *O*, Figure 1. Turning to the ephemeris under the column headed *P*, we obtain by interpolation for our date, the

angle 359°.0. Under column *Q* we obtain 107°.7, subtracting 90° gives us 17°.7. Laying off the natural tangents of those angles on the vertical line, we obtain +1.7 mm and − 31.9 mm. The directions are determined by the description given in the Almanac. Two long lines *s* and *n* are drawn perpendicular to *OP*. and two short lines perpendicular to *OQ*. These lines if prolonged would pass through the center of the circle.

Turning to the ephemeris under *q* we obtain the angle 0″.86 which is so small that we need not trouble to correct it for the error of the angular diameter. Multiplying by 3 we lay off for the phase the distance 2.58 mm on the line *pq* drawn parallel to *OQ*. If we take a radius slightly larger than that of the circle, in this case 15.0 mm, and draw an arc through this point, and centered on the line *pq*, we shall obtain a close approximation to the arc of an ellipse. The length of this radius is most simply obtained by trial The phase drawing is now complete, but when a series of drawings are being made, it is a good plan to copy in the snow cap from one of the previous drawings before beginning to work. This saves time at the telescope, and if it is incorrect, it is a simple matter to correct it. The method employed in making the drawing is described in full in Report No. 9, and need not therefore be repeated here. At the top of the page we record the date, and beneath the figure the times of beginning and ending the drawing of the outlines, also the time required for the shading, the magnification, quality of the seeing, and also the aperture, when a change from that usually employed occurs. These observed data we record in pencil, and the computed results in ink.

To the mean of the times given for the drawing of the outlines we add 5$^h$ to reduce to Greenwich Time, and multiply by $r$ =14°.62, the mean rotation of Mars in one hour.

TABLE I.

MULTIPLICATION TABLE FOR *r*.

| | | | | | |
|---|---|---|---|---|---|
| 1 | 14°.62 | 4 | 58°.48 | 7 | 102°.34 |
| 2 | 29.24 | 5 | 73.10 | 8 | 116.96 |
| 3 | 43.86 | 6 | 88.72 | 9 | 131.58 |

Table I will be found useful when much multiplication is involved. Adding this result to 158°.11 given in the Ephemeris under Central Meridian, gives us the central meridian of the drawing. The latitude of the central point, + 15°.8, is taken from column $D\oplus$. The inclination of the pole towards the Sun, + 23°.5, is taken from column $D\odot$, and the longitude of the Sun as seen from Mars, 78°.6, is given in the column $\odot\,\delta$. The three corresponding columns in the British Nautical

Almanac are headed B, *B*, and ⊙. Taking the last number, and turning to Report No. 10, Table I, column 2, we find in the next column the Martian Date June 2.

These results give all the facts that it is necessary to record regarding any drawing. We may however want to know at what time we should make a drawing in order that a certain longitude should be on the central meridian. Drawings are made here in every 30° of longitude, beginning at 0°. Let us suppose we wished to know when longitude 330° would be central. We look out 330° in Table II and find against it $22^h\ 34^m.2$.

TABLE II.

TIMES OF TRANSIT FOR SELECTED MERIDIANS.

| Merid. | Hour | Merid. | Hour | Merid. | Hour |
|---|---|---|---|---|---|
| ° | h m | ° | h m | ° | h m |
| 30 | 2 03.1 | 150 | 10 15.6 | 270 | 18 28.0 |
| 60 | 4 06.2 | 180 | 12 18.7 | 300 | 20 31.1 |
| 90 | 6 09.4 | 210 | 14 21.8 | 330 | 22 34.2 |
| 120 | 8 12.5 | 240 | 16 24.9 | 360 | 24 37.4 |

Turning to the Ephemeris, in the last column under Mean Time of Transit of Zero Meridian, we find for April 10, $13^h\ 49^m.0$. If we should add this to the number taken from our table, the result would be greater than $24^h$. We must therefore go back to the previous date. This gives us $13^h\ 10^m.8$. Adding the numbers now gives us $35^h\ 45^m.0$ on April 9, or April 10, $11^h\ 45^m.0$ G.M.T. Subtracting $5^h$ to correct to Eastern Standard Time gives us $6^h\ 45^m.0$ as the required result.

In the above computations the rate of rotation 14°.62 has been taken as a constant. This is not strictly true, but its limiting values in any case likely to occur in practice may be taken as 14°.60 and 14°.64. This would give a maximum error of 0°.5 for the longitude of a drawing, and of $2^m$ in the time of transit. The maximum value 14°.64 is only reached at aphelion oppositions, as we then pass Mars more rapidly than we do at perihelion, when it is nearer to us. This at first seems strange, but is accounted for if we recollect that at perihelion Mars is moving more nearly at the same speed as the Earth, so that we stay with it longer. The minimum value 14°.60 is attained when the planet is remote from us, and when very remote and at too great a distance to observe, a still smaller value is reached.

It may be of some interest to the amateur to know what can be seen on Mars with a small telescope. With our 3-inch finder, and a power of 180 on February 27, seeing 5, the Acidalium marsh and the southern maria were both conspicuous. They were also visible with a power of 90. The northern polar cap could be seen with more difficulty. On February 3 the Syrtis and the canals Thoth and Nilosyrtis were clearly

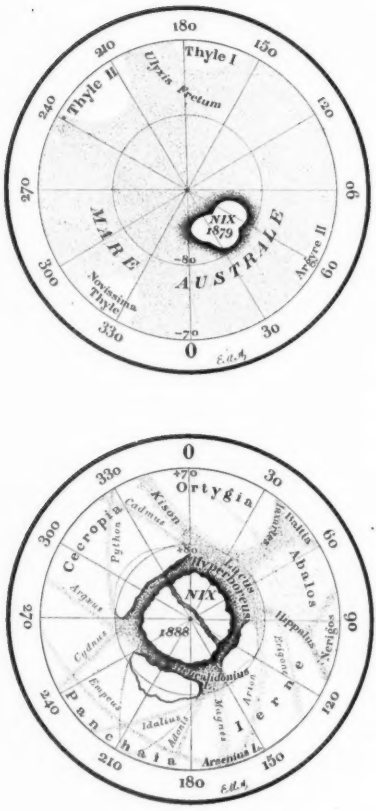
seen. By April all these features will be more difficult, and it is probable that the polar cap will be too small to be visible. We should look at 9$^h$ Eastern Standard Time, or 8$^h$ Central, on or about April 7 for Acidalium, and about April 17 for the Syrtis and the canals. In Report No. 8, Figures 2 and 9 will give an idea of the appearance of the former region, and Figures 22 and 23 of the latter.

We are happy to be able to refer our readers in the future to the excellent map of Flammarion and Antoniadi, published herewith, (Plates XI and XII) which gives many features not contained in that of Schiaparelli, is on a much more convenient projection, and has the great advantage over many maps that have been published of the planet, that it is exceedingly clear, in spite of the fact that the canals are very numerous in certain regions. The type is everywhere sufficiently large to be read, yet is nowhere so obtrusive as to hide the topographical features.

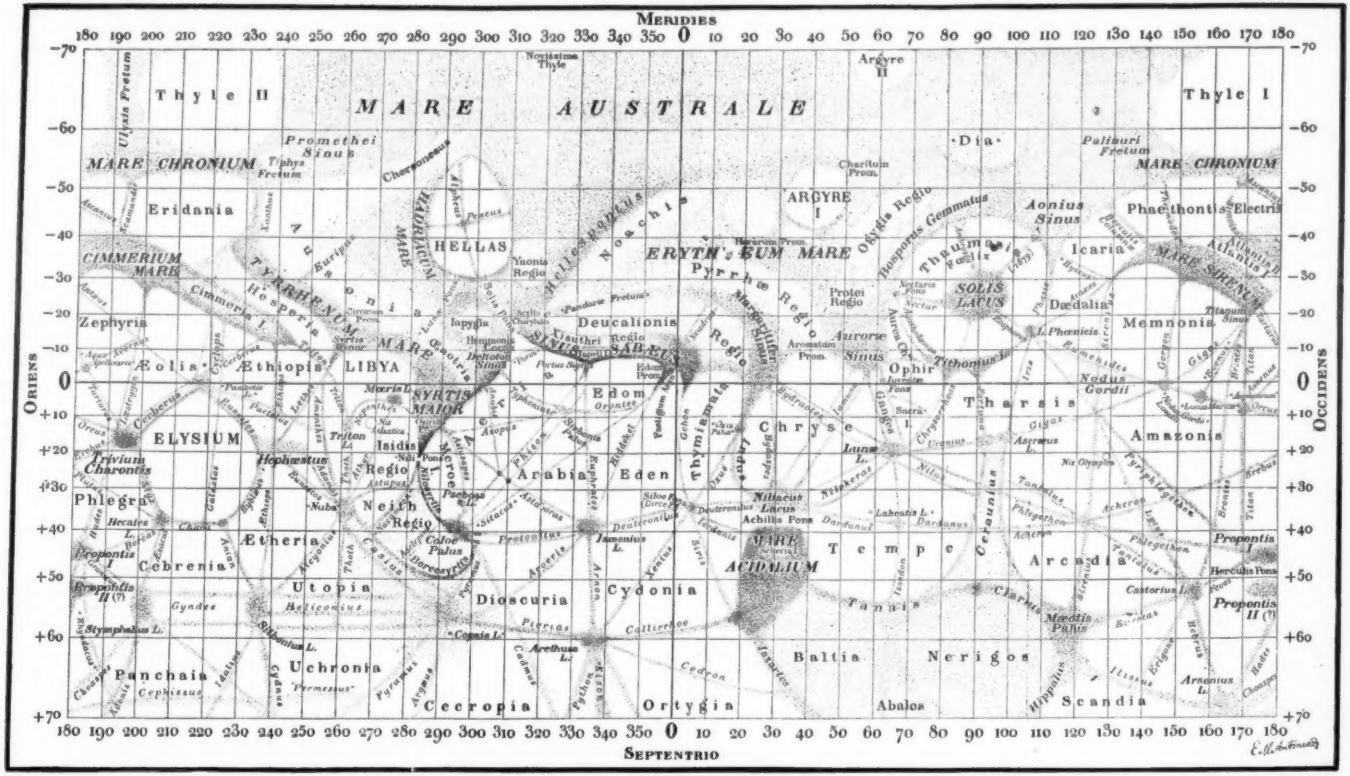
As was shown in our Report No. 9, for all solar longitudes ⊙ exceeding 34°.1, which was passed January 2, 1916, the planet is seen to better advantage at the present opposition than at the last one. During the past winter we have had fewer favorable nights than usual in Jamaica, and these were mostly occupied in making drawings of the planet, a few topographical positions however have been determined. The shifting to the west, that is to higher longitudes, of the Twin Polar Bays has been confirmed. In Report No. 14 a measure is given, made on December 8 of the south preceding end of Castorius, the preceding of the two bays. Its longitude was 135°.6. Two days later we found it 137°.5. Mean 136°.6 ± 1°.0. On January 15 it was 151°.1, and on February 19 practically the same, 151°.8. Mean 151°.4 ± 0°.4. Shift 14°.8. The longitude according to the map is 155°. There is very little water in it now as compared to the previous opposition. It is faint and difficult to see, much more so than last December, and presumably it has dried up. Therefore its advance has practically ceased. In a report just received from Professor Lau in which he writes of a drawing recently sent me, he says it shows Charontis, but that the "details (Phlegra, Propontis) are evidently strongly displaced." Propontis is the companion twin bay.

The position of the southernmost point of Acidalium, known also as Niliacus, was determined February 27, 28, and March 1. Longitudes 33°.9, 37°.3, 36°.9, mean 36°.0 ± 1°.4. Latitudes + 26°.1, + 26°.2, + 23°.2, mean 26°.5 ± 1°.1. Its position according to the map is in longitude 30°, latitude + 28°. The position of Nodus Gordii was determined November 4. It was found to be located in longitude 131°, latitude + 25°. Report No. 13. On account of its unusual northern latitude however, it was not recognized at that time. Its position was again determined January 16, longitude 123°.2, latitude

# PLATE XI


180
150
120
90
60
30
0
330
300
270
240
210
Thyle I
Thyle II
Ultima Thule
Ultima Thule
Ultima Thule

# PLATE XII


MERIDIES
SEPTENTRIO
ORIENS
OCCIDENS
MARE AUSTRALE
MARE CHRONIUM
MARE CIMMERIUM
MARE TYRRHENUM
MARE ACIDALIUM
HELLAS
ERYTHRÆUM MARE
SOLIS LACUS
ARGYRE I
ARGYRE II
Thyle I
Thyle II
Eridania
Zephyria
Æolis
Æthiopis
LIBYA
ELYSIUM
Phlegra
Cebrenia
Ætheria
Panchaia
Uchronia
Utopia
Cecropia
Ortygia
Dioscuria
Cydonia
Baltia
Nerigos
Abalos
Scandia
Arcadia
Amazonis
Memnonia
Icaria
Daedalia
Phaethontis
Electris
Aonius Sinus
Ophir
Tharsis
Chryse
Eden
Arabia
Deucalionis Regio
Aurorae Sinus
Aromatum Prom.
Tithonius L.
Ogygis Regio
Protei Regio
Pyrrhae Regio
Nochis
Thymiamis Regio
Iapygia
Taonia Regio
Neith Regio
Isidis Regio
Hephæstus
Trivium Charontis
Cerberus
Hesperia
Propontis I
Propontis II (?)
Hercules Pons
Cassius
Ulyxis Fretum
Promethei Sinus
Palinuri Fretum
Charontes
Tiphys Fretum
Xanthus
Scamander
Simois
Hiddekel
Euphrates
Gihon
Pison
Indus
Ganges
Araxes
Jaxartes
Oxus
Laestrygonum Thyle
Charitum Prom.
Nectaris Fons
Nectar
Ambrosia
Hydaspes
Lucus Phoebes
Lucus Veneris
Sirenum Scopuli
Titanum Sinus
Memnonis Sinus
Gordii Nodus
Gigas L.
Asgrus L.
Lunae L.
Niliacus Lacus
Achillis Pons
Labeatis L.
Dardanus
Cerberus
Orcus
Styx
Lethe
Acheron
Phlegethon
Cocytus
Tartarus
Erebus
Titan
Cimmerii
Tanais
Maeotis Palus
Cimmeria
Sithonius L.
Arethusa L.
Cecropia L.
Cerberus L.
Hecates L.
Chaos
Nubia
Gyndes
Hesperia
Cimmeria
Tyrrhenum Mare
Hellespontus
Nochis
Pyrrhae Regio
Thymiamis Regio
Aurorae Sinus
Ogygis Regio
Protei Regio
Deucalion

+18°. According to the map its mean longitude is 126°, and its latitude + 9°. We are very certain of the accuracy of our result in January, because owing to the inclination of the planet's axis, the point measured lay in the exact center of the disk. This seems to be a clear case of shift in latitude. By the time it was due to be seen in February, it had completely faded out. In the light of this shifting of details, it is now seen that the second drawing in Figure 2 of Report No. 5 refers to the Nodus Gordii, and not to Sirenum. The position there determined was in longitude 143°, latitude + 9°. This is not far from Lowell's position as given on the map, 146° and +1°.

The longitude of Thoth in latitude + 30° was determined February 2 as 261°.2 and February 3 as 256°.7. Mean 259°.0 ± 2°.2. This seems rather a large deviation, 80 miles, and the measure should be repeated. According to the map the longitude is 262°. In this connection it may be mentioned that this canal is really Thoth, and not Amenthes as has been suggested by some. Amenthes is connected with Nilosyrtis by the Tyrrhenum Mare in latitude −10°. Thoth is connected with it by Nepenthes in latitude + 5°. The latitude of the connecting canal was measured on a drawing made February 2, ω 270°.8. Where the canal crossed the central meridian its latitude was + 6°.4. It is therefore Nepenthes, and the canal in question Thoth.

Three determinations have been made of the position of Titanum. December 8 its longitude was 156°.2, January 15, 155°.4, and February 19, 157°.7. Mean 156°.4 ± 0°.8. According to the map it is 170°, a difference of 13°.6. This is equivalent to 500 miles! The latitudes on these three dates were − 22°.9, − 18°.7, and − 22°.5. Mean −21°.4 ± 1°.8. According to the map its latitude is −20°. Difference 50 miles. An examination of the drawings confirms this shift, and makes it clear that Titanum has certainly moved away from Elysium. On our drawings of February 7, 9, and 12 it was also clear that the large bay similar to Titanum which was visible at the last opposition, had reappeared at the mouth of Laestrigon. In Report No. 5 we found evidence of a considerable shift in the longitude of Titanum, ranging from 162° early in the season, to 175° towards the end. Titanum was one of the points suggested for general observation this year in Report No. 13, and it is hoped that it may have been located by some other observer.

Certain of the more accessible Associates have been notified by mail of these observations, with the request that they be repeated. Their main importance lies in the fact that if the more conspicuous features of the planet shift about over its surface indiscriminately, no determination of the period of rotation based on observations of a single feature, continued through the period of the few years of any one

man's observing life should have much weight, but for the present we must still depend on a comparison of our results with the earliest recognizable drawings of the planet.

Another point of importance is that if the canals shift laterally through several hundred miles, it is useless to make maps covered with scores of canals located only a few miles apart, and only a few of which are seen at any one time. It would obviously be idle to give the Syrtis canal one name on Dr. Lowell's map, to give it another on that of Mr. Lau, and to give it still a third in the present investigation. About 800 canals have now been named. It is better to confine ourselves to perhaps a hundred names, such as are shown on the present map, rather than burdening our memories with the names and locations of 700 minor canals, which would be of no particular importance, even supposing that they had a separate individual existence. As an example of what is proposed, it may be mentioned that on February 12 a new canal appeared joining Cerberus, and lying between Antaeus and Tartarus, neither of which was then visible. Instead of giving it a new name, it is proposed in such a case to designate it simply as [Tartarus-Antaeus]. Should all three canals appear later at once, which is very unlikely, it might then be time to change the designation of the present one.

A few exceptions to this rule may be necessary. Thus it is clear that the little canal recorded in 1913-14 joining Juventae to Aurorae was not identical with Ganges, and might very well appear at the same time with it. In his map of 1896 Lowell shows two small canals Baetis and Hebe connecting with Juventae. In Report No. 8, Figures 6 and 8, the canal shown coincides most nearly with Baetis. This name will therefore be adopted hereafter to designate it. This is the only instance hitherto recognized where it seems necessary to go outside of the present map for a name.

On January 23, $\omega$ 27°.6, M. D. April 39, Margaritifer appeared here for the first time this opposition. It was certainly invisible December 20 and 25, M. D. April 6 and 11. It was now well developed, and quite dark. Sabaeus was also clearly seen. Its southern boundary was beginning to take form, but its western end was still quite undeveloped. The next night both were well marked, but it was only on January 30 that its whole outline was complete and strongly defined. No trace of Aryn had yet appeared, 343°.7, corresponding M.D. April 45. Neither was it seen on February 28, $\omega$ 30°.4, M.D. May 18. It was suspected however two nights later, and in a few days became clearly visible. In the light of the lateness of its appearance at the present opposition, and my inability to see it at all at the previous

one, even when carefully looked for, I cannot believe that it was visible at that time, although shown in the Martian months of March and April by several other observers.

On January 23 was also recorded the first appearance of brown supposed on the green of the southern maria, to the south of Margaritifer and Aurorae. Although this was the latter part of April on Mars, we must remember that we are now dealing with their southern hemisphere, so that it is their autumn of which we are speaking. The first greens were detected on the planet at this opposition on February 44, in this same region, Report No. 12, so that their duration was 107 days, or three and a half of our months.

In our last Report, for December, we called attention to the gradual drying up of the Syrtis marsh since its first appearance on October 23, and found that our observations were confirmed by Professor Douglass on the nights of November 28 and December 3. A report and drawing recently received from another Associate, Mr. W. F. Gale, in Australia further confirms this statement, and shows that on December 12 the northern tip of the Syrtis was appreciably *lighter* than regions further south, the darker regions lying along the western side, and extending only to latitude + 10°. Its color was grey, the polar sea being a light steel blue at the time. He was much impressed by a brilliant cloud immediately following the Syrtis when near the limb, and which later dissolved, exposing the intense red of the desert regions in its place. On December 26 we recorded that there was no evidence whatever of the Syrtis marsh.

Five days later, January 1, the marsh and polar sea were both conspicuous, bright blue, and equally dark. The marsh was the bluer of the two, and its eastern side was lighter and bluer than the western. No observations were possible here during this interval, and as far as heard from in response to the query in our last Report, no observations seem to have been made in the United States between December 26 and January 1. If such is the case it is regrettable, since this region could not have been well seen in Europe during this period. It was suggested in Report No. 9 that changes on Mars in the region of the Syrtis might be expected during these months, and the dates when it could be well seen were computed and indicated in Table I, in order to aid would be observers.

Although on our drawing of January 1, Casius, usually a very dark marking, must have stretched from within 15° to 35° from the central meridian, on the side of the terminator, yet it was not recorded. The whole surrounding region was extremely dark. On our next drawing January 4, $\omega 270°$, Casius is shown, but it was no darker than its continuation Thoth, and it looked as if it might have been drained of its

superfluous moisture to fill the Syrtis. The next night it was much darker, and appeared to have partially recovered. In a note to the writer Mr. Lau speaks of the invisibility of Casius in a "preceding observation", made presumably in December. The maria preceding the Syrtis were now distinctly green.

When next seen, January 30, the marsh was still bluish, and this color was retained until February 4, but three days later it had disappeared. A projection of the marsh into Nepenthes was formed between January 30 and February 2, and a dark extention to the west of the northern tip, blunting it, and yet further increasing its longitude appeared February 2. A very large but much paler extension further south, and probably brownish in color reaching 1000 miles to the eastward also appeared. Its length was further increased by 500 miles the next night, and at the same time the southeastern end of the marsh retreated several hundred miles. Presumably it dried up. A special drawing was made to indicate this change, which was quite marked. This was confirmed two nights later, when the marsh appeared still smaller, but by February 9 and again February 11 was as large as ever.

On February 4, M. D. April 50, the planet was compared with the colored sketch Figure 1 shown in November number of POPULAR ASTRONOMY, and distributed in connection with the Index to the first ten reports. The sketch was illuminated by a 9 c. p. tungsten lamp shining through a blue medium, of such density that the snow of the planet appeared of the same tint as the white paper. The magnification employed was 660, and the aperture was reduced to five inches, so that the planet and the colored sketch appeared of the same brilliancy. It was recorded that the snow, deserts, and south polar regions were now correct, the greens, and Syrtis were of the proper darkness, and with good seeing of very nearly the right color, though possibly a trifle too green. The better the seeing, the greener they appeared.

Two nights later the maria were recorded as grey not green, and the next night as brown, like the maria south of Acidalium, seeing 9. This color we take, as above suggested to be a ripening of vegetation, analogous to the change of leaf in our fall. By February 9 the brown area had reached the junction of Laestrigon, some 3000 miles from its origin at the Syrtis, the mean rate of travel having been something like 300 miles per day. This termination of the season on Mars seems to be a very sharply marked phenomenon, which should be looked for in future years. It appears to be even more distinct than the first appearance of the greens previously noted. There seemed to be a similar brown extension starting westerly from the Syrtis, but when last seen February 11 it had not progressed very far. If really due to

a change of leaf, it would indicate that in latitudes $-10°$ to $-30°$ the frosts came this year between April 39 and 53, or in what would correspond with us to early November. Compare the third and fourth columns of the Calendar, Report No. 10. A similar change occurs in our northern New England States in latitude $+45°$ about the last of September. In latitude 20° on the Earth there is of course no change of leaf.

The south polar regions throughout the whole of this period appeared of a greenish yellow, but it is believed that yellow was more nearly its true color, and that the green was mainly a contrast effect. The clouds frequently seen in Elysium following Charontis, Styx, and Cerberus, and also those seen following Thoth and Nilosyrtis, indicate to us that these canals are all of the same nature as Acidalium, which is always followed by a cloud. In other words they seem all to be of a marshy character, rather than canals due to vegetation. Indeed on one occasion it was thought that faint traces of polarization were detected in Nilosyrtis. These clouds sometimes persist all the way across the face of the planet, but usually they disappear or are very faint after noon.

On February 7, $\omega$ 232°, there was a bright cloud filling the space between Thoth and Nilosyrtis, but two hours later it had vanished and the intervening space was unusually dark, brightness 5, giving the impression of moistened ground, as if there had been rain. Irrespective of the latitude, $-20°$, thawing does not seem likely under the conditions observed, while rain seems a possible explanation. These cloud changes sometimes take place with great rapidity. Thus on February 12, $\omega$ 172°, there was a large cloud on the limb following Nilosyrtis, reaching as far as the southern maria, and covering 0.12 of the whole disk. Within half an hour the northern two-thirds of this cloud had entirely vanished. This cloudy region must have covered 2,000,000 square miles of surface. These clouds frequently stop at the edge of the maria.

Another comparison with the colored print was made February 25, $\omega$ 46°, M. D. May 15. The deserts of the print were now not quite red enough, and the marsh clearly not as blue as on the planet. The greens on Mars had now faded completely, and were replaced by a brownish grey tint. It may be noted here that the brown in Figure 2 is too intense and the greens, rather too blue. It is unfortunate that our forwarding agent was unable to send us a torch capable of holding a 9 c. p. lamp before the end of January, so that no satisfactory measures were possible at the beginning of the Martian season, but some made with a lamp of 2 c. p. indicate that the greens shown in the two sketches were then very nearly correct. There is some evidence that Acidalium is now drying up, and losing its blue color.

Two more reports, illustrated in colors, have been received from our Associate Mr. McEwen, extending from November 1 to December 25. His source of illumination is a lamp burning cycle lamp oil, which at 4 c. p. and at a convenient distance, renders the paper slightly brighter than the planet. Although the writer uses the white filament of a tungsten lamp, rendered still more blue by blue glass or blue gelatin film, until its color approximates that of daylight, yet both observers agree closely as to the color of the desert regions of the planet. At certain times appear rather less red to the writer, at others we exactly agree. This is rather surprising, since we should naturally suppose that a bluer illumination would require a redder pigment. It is only when we come to the greens and blues that a notable difference appears in our results. To Mr. McEwen these regions usually appear brown or greyish. He uses colored crayons in preference to water colors, as the writer does in part, Report No. 9, and the tint he most frequently mentions is gold ochre. He also mentions light and brown ochre, burnt and brown yellow, raw umber, sepia, Van Dyke brown, and Venetian red.

Some of his more interesting observations follow. On November 3 Acidalium was on the central meridian, color raw umber. It was very faint, and not nearly so dark as Aurorae. This is certainly unusual, and can only be explained by heavy cloud over the marsh. He mentions particularly the bright white cloud following it. Margaritifer and Aurorae appeared as a dark band, that is to say the former had not yet developed as a bay. This is further confirmed November 10, when he records Protonilus, Ismenius, and Deuteronilus all prominent, and much darker than Sabaeus or Margaritifer, which later appeared as a faint band stretching across the southern part of the disk. A small white spot, [i.e. a cloud] was visible at the center of the disk $\lambda 354°$, $\delta + 20°$. November 19 Syrtis Major was very faint when nearly half way to the center, and not so dark as Nilosyrtis or Boreosyrtis. This further confirms the drying up of the Syrtis at this period, following its first inundation in October.

December 12. Hiddekel and Gehon were seen together as a very faint broad and diffused band extending from the bay of Sabaeus towards Ismenius and Dirce. This is the broad north and south band to which frequent reference was made in our earlier reports. Sabaeus bay was distinct, of triangular shape, with a sharp northern boundary. Aryn had therefore not developed by that date. The bay was less distinct an hour later, when it had passed the central meridian. The southern edge of Thymiamata, Chryse and Ophir appeared as a white line, lying in an east and west direction. Margaritifer therefore had not yet developed. We have just seen that it did not appear in Jamaica as a bay until six weeks later, January 23.

Table III contains the usual data of the month's drawings.

TABLE III.

DATA OF THE DRAWINGS.

| No. | 1916 | ⊙ | M. D. | Long. | Lat. | Sun | Diam. | Seeing |
|---|---|---|---|---|---|---|---|---|
| | | ° | | ° | ° | ° | ″ | |
| 42 | Jan. 1 | 35.1 | Apr. 17 | 295 | +19 | +14 | 11.4 | 5, 4 |
| 43 | " 4 | 36.4 | " 20 | 270 | " | " | 11.7 | 5, 4 |
| 44 | " 5 | 36.9 | " 21 | 242 | " | " | 11.8 | 6 |
| 45 | " 12 | 40.0 | " 28 | 203 | " | 15 | 12.4 | 5 |
| 46 | " 15 | 41.4 | " 31 | 155 | 18 | 16 | 12.7 | 8, 10 |
| 47 | " " | " | " " | 180 | " | " | " | 8, 7 |
| 48 | " 16 | 41.7 | " 32 | 92 | " | " | 12.8 | 8, 9 |
| 49 | " " | " | " " | 117 | " | " | " | 8, 9 |
| 50 | " 17 | 42.1 | " 33 | 66 | " | " | " | 8, 7 |
| 51 | " 23 | 44.8 | " 39 | 28 | " | 17 | 13.3 | 6, 7 |
| 52 | " 24 | 45.2 | " " | 7 | " | " | 13.4 | 7, 6 |
| 53 | " 30 | 47.9 | " 45 | 314 | 17 | 18 | 13.7 | 6, 7 |
| 54 | " " | " | " " | 344 | " | " | " | 9 |
| 55 | " 31 | 48.3 | " 46 | 297 | " | " | " | 6, 8 |
| 56 | Feb. 2 | 49.2 | " 48 | 271 | " | " | 13.8 | 8, 7 |
| 57 | " 3 | 49.6 | " 49 | 258 | " | " | " | 10 |
| 58 | " 7 | 51.4 | " 53 | 242 | 16 | " | 13.9 | 9 |
| 59 | " 9 | 52.3 | " 55 | 216 | " | 19 | " | 8, 6 |
| 60 | " " | " | " " | 310 | " | " | " | 4 |
| 61 | " 12 | 53.6 | May 2 | 179 | " | " | 13.8 | 10 |
| 62 | " " | " | " " | 268 | " | " | " | 5 |
| 63 | " 19 | 56.6 | " 9 | 120 | 15 | 20 | 13.6 | 8, 7 |
| 64 | " " | " | " " | 153 | " | " | " | 7, 6 |
| 65 | " 24 | 58.8 | " 14 | 90 | " | " | 13.3 | 6, 7 |
| 66 | " " | " | " " | 126 | " | " | " | 6, 6 |
| 67 | " 26 | 59.7 | " 16 | 61 | " | " | 13.2 | 7 |

The following canals and lakes were seen:—

Jan. 1 **F** Nilosyrtis.

Jan. 4 **F** Nilosyrtis, Thoth, Astusapes.

Jan. 5 **E** Nilosyrtis, Thoth, Astusapes, Casius, Hephaestus, Eunostos, Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Aesacus.

Jan. 12 **D** Casius, Cyclops, Cerberus, Chaos.

Jan. 15 **D** Eunostos, Cyclops, Cerberus, Chaos, [Tartarus-Antaeus], Brontes, and Nodus Gordii.

Jan. 16 **C** Brontes, Tantalus, Sirenus, Acheron, Tithonius, Eosphoros, Nectar, Ceraunius, Nilokeras, and Phoenices, Solis, Lunae.

Jan. 17 **B** Ceraunius, Nilokeras, Ganges, Tithonius, Nectar, and Solis, Lunae.

Jan. 23 **A** Nilokeras, Ganges, Tithonius, Nectar, Indus.

Jan. 24 **A** Deuteronilus, Protonilus.

Jan. 30 **FA** Protonilus, Nilosyrtis, Thoth, Casius, Indus, Oxus, Deuteronilus, Sitacus, and Ismenius, Moeris.

Jan. 31 **F** Deuteronilus, Arnon, Protonilus, Astusapes, Nilosyrtis, Nepenthes, Thoth, Casius, and Ismenius.

Feb. 2 **F** Protonilus, Nilosyrtis, Nepenthes, Thoth, Casius, Hephaestus, Cyclops, Eunostos, Hyblaeus.

Feb. 7 **E** Nilosyrtis, Nepenthes, Thoth, Casius, Hephaestus. Eunostos, Cyclops, Cerberus, Hades, Styx, Aesacus, Chaos, Hyblaeus.

Feb. 9 **EF** Nepenthes, Thoth, Casius, Hephaestus, Eunostos, Cyclops, Cerberus, Erebus, Hades, Chaos, Hyblaeus, Protonilus, Nilosyrtis.

Feb. 12 **DE** Eunostos, Cyclops, Cerberus, Tartarus, Laestrigon, Avernus, Styx, Chaos, Hyblaeus, Hades, Erebus, Nilosyrtis, Nepenthes, Thoth, Casius.

Feb. 19 **CD** Tantalus, Acheron, Ceraunius, Cerberus, Hades, Erebus.

Feb. 24 **C** Acheron, Ceraunius, Nilokeras, Tithonius, Iris, Fortuna, Nectar, Ganges, Tantalus, and Solis, Tithonius.

Feb. 26 **B** Ceraunius, Nilokeras, Tithonius, Fortuna, Nectar, Bosporus, Ganges, and Solis, Tithonius, Lunae.

These canals except Astusapes were all broad, often several hundred miles in width, never less than one hundred. As a rule they were curved rather than straight. With the coming of March a different type of canal appeared, both narrow and straight. No duplications have hitherto occurred, but with the coming of the new type new phenomena may appear.

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## ARCTURUS—RISING.

Again Arcturus beams!—his gleaming light
Burns brilliantly amidst the star-lit night,
Like harbinger in yonder eastern sky
He rises to proclaim that spring is nigh;
When winter's snow still lies on hill and vale,
And winds of March first wander down the dale,
Ere crocus blooms or falls mild April's rain,
Like beacon bright Arcturus beams again.

CHARLES NEVERS HOLMES.

Newton, Mass.
41 Arlington St.

## PLANET NOTES FOR MAY, 1916.

CLIFFORD C. CRUMP.

The sun will move during the month by a northeasterly course from Aries into Taurus. About the middle of the month it will be near the region of the Pleiades.

THE CONSTELLATIONS AT 9:00 P. M. MAY 1.

The phases of the moon for this month are as follows:

| | | | | |
|---|---|---|---|---|
| New Moon | May 1 | at 11 | P.M. | C.S.T. |
| First Quarter | 10 | " 3 | A.M. | " |
| Full Moon | 17 | " 8 | A.M. | " |
| Last Quarter | 23 | " 11 | P.M. | " |
| New Moon | 31 | " 2 | P.M. | " |

*Mercury* will continue its eastward motion from the sun until May 27. It will then move in a retrograde direction for the remainder of the month. It will not be in a favorable position for observation.

*Venus* will be in a good position for observation during the month. It will pass from the constellation of Taurus into the constellation of Gemini.

*Mars* will have an easterly motion and move from the constellation of Cancer into the constellation of Leo. It will cross the meridian early in the evening.

*Jupiter* will appear in the morning sky in the constellation of Pisces.

*Saturn* will continue to be visible in the early evening low in the western sky in the constellation of Gemini.

*Uranus* may be seen in Capricornus in the early morning.

*Neptune* will be visible in the early evening in the constellation of Cancer a few hours east of Saturn.

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**Occultations Visible at Washington.**

| Date 1916 | Star's Name | Magnitude | IMMERSION. Washington M.T. | Angle from N. | EMERSION. Washington M.T. | Angle from N. | Duration |
|---|---|---|---|---|---|---|---|
| | | | h m | ° | h m | ° | h m |
| May 8 | θ Cancri | 5.5 | 10 43 | 66 | 11 21 | 345 | 0 37 |
| 19 | 86 B Sagittarii | 6.5 | 10 49 | 158 | 11 14 | 202 | 0 25 |
| 20 | 53 Sagittarii | 6.3 | 13 53 | 121 | 14 45 | 204 | 0 52 |
| 20 | 274 B Sagittarii | 6.1 | 14 6 | 129 | 14 49 | 195 | 0 43 |

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**Mars at the Opposition 1915-16.**—The following notes concerning the planet Mars have been received as Observation Circulars from Professor Percival Lowell, director of the Lowell Observatory:

Flagstaff, Arizona
March 8, 1916.

"The Martian canals in the region Aeria, from forty degrees north latitude to six degrees south latitude, the Euphrates, Phison and others, at present observed near the center of the disk, have darkened appreciably since the last presentation five weeks ago, showing the quickening effect from the north polar melting."

Flagstaff, Arizona.
March 9, 1916.

"The frost on Hellas, the mid-latitude of which is forty-five degrees, where the South Polar Cap is now in process of forming, diminished strikingly between the evenings of March 7th, and 8th. The season in the northern hemisphere of Mars now corresponds to November 26th on the earth."

Flagstaff, Arizona.
March 14, 1916.

"Canals in Mare Erythraeum have faded out since its last presentation. The Mare is now a light chocolate tint in contrast to blue-green markings elsewhere. Martian season in southern hemisphere corresponds to November 27th."

## VARIABLE STARS.

### Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1916.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

| Name. | R. A. 1900. h m | Decl. 1900. ° ′ | Magn. | Name. | R.A. 1900 h m | Decl. 1900 ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| X Androm. | 0 10.8 | +46 27 | 10.0 *i* | W Aurigae | 5 20.1 | +36 49 | 13.3 |
| T Androm. | 17.2 | +26 26 | 13.4*d* | S Aurigae | 20.5 | +34 4 | 8.4 *i* |
| T Cassiop. | 17.8 | +55 14 | 8.6 | S Orionis | 24.1 | — 4 46 | 11.1*d* |
| R Androm. | 18.8 | +38 1 | 14.2*d* | S Camelop. | 30.2 | +68 45 | 10.3*d* |
| Y Cephei | 31.3 | +79 48 | 11.2*d* | T Orionis | 30.9 | — 5 32 | 10.0 |
| U Cassiop. | 40.8 | +47 43 | 14.0*d* | U Aurigae | 35.6 | +31 59 | 14.0*d* |
| RW Androm. | 41.9 | +32 8 | 13.7 | SU Tauri | 43.2 | +19 2 | 9.5 |
| V Androm. | 44.6 | +35 6 | 13.0*d* | Z Tauri | 46.7 | +15 46 | 14.0*d* |
| RR Androm. | 45.9 | +33 50 | 14.5*d* | RU Tauri | 46.9 | +15 57 | 13.1 |
| RV Cassiop | 47.1 | +46 53 | 14.5*d* | V Camelop. | 49.4 | +74 30 | 10.8*d* |
| W Cassiop. | 49.0 | +58 1 | 9.5 *i* | U Orionis | 49.9 | +20 10 | 11.1 *i* |
| Z Ceti | 1 1.6 | — 2 1 | 9.5 *i* | Z Aurigae | 53.6 | +53 18 | 10.0 |
| U Androm. | 9.8 | +40 11 | 13.0*d* | X Aurigae | 6 4.4 | +50 15 | 12.1*d* |
| UZ Androm. | 10.4 | +41 12 | 12.5 *i* | SS Aurigae | 5.8 | +47 46 | <13.5 |
| S Cassiop. | 12.3 | +72 5 | 14.4*d* | V Aurigae | 16.5 | +47 45 | 11.2*d* |
| S Piscium | 12.4 | + 8 24 | 9.8*d* | V Monoc. | 17.7 | — 2 9 | 9.0*d* |
| U Piscium | 17.7 | +12 21 | 11.0*d* | U Lyncis | 31.8 | +59 57 | 12.8 |
| RZ Persei | 23.6 | +50 20 | 12.4 *i* | S Lyncis | 35.9 | +58 0 | 12.4*d* |
| R Piscium | 25.5 | + 2 22 | 13.0*d* | X Geminorum | 40.7 | +30 23 | 12.8 |
| RU Androm. | 32.8 | +38 10 | 14.0*d* | W Monoc. | 47.5 | — 7 2 | 11 8*d* |
| Y Androm. | 33.7 | +38 50 | 14.0*d* | Y Monoc. | 51.3 | +11 22 | 12.9*d* |
| X Cassiop. | 49.8 | +58 46 | 10.8 *i* | R Lyncis | 53.0 | +55 28 | 8.3 |
| U Persei | 53.0 | +54 20 | 8.5*d* | R Geminorum | 7 1.3 | +22 52 | 11.7*d* |
| S Arietis | 59.3 | +12 3 | 11.7 *i* | V Can. Min. | 1.5 | + 9 2 | <14.0*d* |
| R Arietis | 2 10.4 | +24 35 | 8.4 *i* | R Can. Min. | 3.2 | +10 11 | 10.0 |
| W Androm. | 11.2 | +43 50 | 8.7 *i* | RR Monoc. | 12.4 | + 1 17 | 10.5 *i* |
| Z Cephei | 12.8 | +81 13 | 10.0 *i* | V Geminorum | 17.6 | +13 17 | <13.0 |
| *o* Ceti | 14.3 | — 3 26 | 5.1*d* | S Can. Min. | 27.3 | + 8 32 | 9.5*d* |
| S Persei | 15.7 | +58 8 | 8.7 | Z Puppis | 28.3 | −20 27 | <13.5 |
| R Ceti | 20.9 | — 0 38 | 11.0*d* | T Can. Min. | 28.4 | +11 58 | 13.0*d* |
| RR Persei | 21.7 | +50 49 | 13.7*d* | U Can. Min. | 35.9 | + 8 37 | 8.4 |
| U Ceti | 28.9 | −13 35 | 12.0*d* | S Geminorum | 37.0 | +23 41 | 13.5 *i* |
| RR Cephei | 29.4 | +80 42 | 9.8 *i* | T Geminorum | 43.3 | +23 59 | 13.2*d* |
| R Trianguli | 31.0 | +33 50 | 5.4 *i* | U Geminorum | 49.2 | +22 16 | <13.5 |
| W Persei | 43.2 | +56 34 | 10.0 | U Puppis | 56.1 | −12 34 | 14.0 |
| U Arietis | 3 5.5 | +14 25 | 9.0 *i* | R Cancri | 8 11.0 | +12 2 | 9.2 *i* |
| X Ceti | 14.3 | — 1 26 | 11.3*d* | V Cancri | 16.0 | +17 36 | 8.2 |
| Y Persei | 20.9 | +43 50 | 9.5 | RT Hydrae | 24.7 | — 5 59 | 8.0 |
| R Persei | 23.7 | +35 20 | 12.8 *i* | U Cancri | 30.0 | +19 14 | 13.5*d* |
| T Eridani | 51.0 | −24 20 | 8.0 | X Urs. Maj. | 33.7 | +50 30 | <13.0 |
| W Tauri | 4 22.2 | +15 49 | 9.0 | S Hydrae | 48.4 | + 3 27 | 10.5*d* |
| R Tauri | 22.8 | + 9 56 | 13.8 | T Hydrae | 50.8 | — 8 46 | 10.0*d* |
| S Tauri | 23.7 | + 9 44 | 14.8 | T Cancri | 51.0 | +20 14 | 9.5 |
| T Camelop. | 30.4 | +65 57 | 9.1 *i* | S Pyxidis | 9 0.7 | −24 41 | 13.0*d* |
| X Camelop. | 32.6 | +74 56 | 9.5 *i* | W Cancri | 4.0 | +25 39 | 12.5 *i* |
| RX Tauri | 32.8 | + 8 9 | 11.5*d* | X Hydrae | 30.7 | −14 15 | 8.5 *i* |
| V Tauri | 46.2 | +17 22 | 13.5*d* | Y Draconis | 31.1 | +78 18 | 13.0 *i* |
| R Orionis | 53.6 | + 7 59 | 10.3 *i* | R Leo. Min. | 39.6 | +34 58 | 7.8*d* |
| R Leporis | 55.0 | −14 57 | 9.0*d* | RR Hydrae | 40.4 | −23 34 | 11.0 *i* |
| T Leporis | 5 0.6 | −22 2 | 10.4*d* | R Leonis | 42.2 | +11 54 | 8.6*d* |
| V Orionis | 0.8 | + 3 58 | 11.3*d* | Y Hydrae | 46.4 | −22 33 | 6.6 |
| R Aurigae | 9.2 | +53 28 | 9.0 *i* | V Leonis | 54.5 | +21 44 | 13.0*d* |

**Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1916**—Continued.

| Name. | R. A. 1900. h m | Decl. 1900 ° ′ | Magn. | Name. | R. A. 1900. h m | Decl. 1900 ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| R Urs. Maj. | 10 37.6 | +69 18 | 10.0*d* | S Librae | 15 15.6 | −20 2 | 9.0*d* |
| V Hydrae | 46.8 | −20 43 | 6.6 | S Serpentis | 17.0 | +14 40 | <14.0 |
| W Leonis | 48.4 | +14 15 | 12.8 | S Cor. Bor. | 17.3 | +31 44 | 7.0 |
| S Leonis | 11 5.7 | + 6 0 | 13.5 | RS Librae | 18.5 | −22 33 | <12.0 |
| R Com. Ber. | 59.1 | +19 20 | <13.0 | RU Librae | 27.7 | −14 59 | <12.0 |
| SU Virginis | 12 0.0 | +12 56 | 12.5 | S Urs. Min. | 33.4 | +78 58 | 10.0 *i* |
| T Virginis | 9.5 | − 5 29 | 9.5 *i* | R Cor.Bor. | 44.4 | +28 28 | 6.0 |
| R Corvi | 14.4 | −18 42 | 8.4 *i* | X Cor. Bor. | 45.2 | +36 35 | <13.0*d* |
| SS Virginis | 20.1 | + 1 19 | 8.2*d* | V Cor. Bor. | 46.0 | +39 52 | 9.0*d* |
| T Can. Ven. | 25.2 | +32 3 | 10.3 *i* | R Serpentis | 46.1 | +15 26 | 8.8 *i* |
| Y Virginis | 28.7 | − 3 52 | 10.6*d* | Z Cor. Bor. | 52.2 | +29 32 | <13.0 |
| T Urs. Maj. | 31.8 | +60 2 | 12.8 | U Serpentis | 16 2.5 | +10 12 | 10.0 *i* |
| R Virginis | 33.4 | + 7 32 | 8.8*d* | R Urs. Min. | 31.3 | +72 28 | 9.5 *i* |
| RS Urs. Maj. | 34.4 | +59 2 | 12.5*d* | R Draconis | 32.4 | +66 58 | 8.5 *i* |
| S Urs. Maj. | 39.6 | +61 38 | 8.4*d* | RV Herculis | 56.8 | +31 22 | 11.3 *i* |
| RU Virginis | 42.2 | + 4 42 | 12.3 | T Draconis | 17 54.8 | +58 14 | 12.3*d* |
| U Virginis | 46.0 | + 6 6 | 11.0 *i* | V Draconis | 56.3 | +54 53 | <13.5 |
| V Virginis | 13 22.6 | − 2 39 | <12.0 | W Draconis | 18 5.4 | +65 56 | 11.0*d* |
| R Hydrae | 24.2 | −22 46 | 8.0 *i* | X Draconis | 6.8 | +66 8 | 10.2 |
| S Virginis | 27.8 | − 6 41 | 8.8*d* | SV Draconis | 31.2 | +49 18 | 12.0 *i* |
| T Urs. Min. | 32.6 | +73 56 | 13.5*d* | U Draconis | 19 9.9 | +67 7 | 11.3*d* |
| R Can. Ven. | 44.6 | +40 2 | 8.3*d* | X Cephei | 21 3.6 | +82 40 | 13.3*d* |
| Z Bootis | 14 1.7 | +13 59 | 12.0*d* | T Cephei | 8.2 | +68 5 | 6.5 |
| Z Virginis | 5.0 | −12 50 | 12.0 | S Cephei | 36.5 | +78 10 | 9.5 |
| U Urs. Min. | 15.1 | +67 15 | 9.3*d* | SS Cygni | 38.8 | +43 8 | 11.8 |
| S Bootis | 19.5 | +54 16 | 13.3*d* | S Lacertae | 22 24.6 | +39 48 | 12.8 |
| RS Virginis | 22.3 | + 5 8 | <13.0 | R Lacertae | 38.8 | +41 51 | 12.8*d* |
| R Camelop. | 25.1 | +84 17 | 9.8 *i* | V Cassiop. | 23 7.4 | +59 8 | 12.6*d* |
| V Bootis | 25.7 | +39 18 | 9.8*d* | Z Androm. | 28.8 | +48 16 | 8.6 |
| R Bootis | 32.8 | +27 10 | 12.0*d* | Z Cassiop. | 39.7 | +56 2 | <13.5 |
| U Bootis | 49.7 | +18 6 | 10.5 | RR Cassiop. | 50.7 | +53 8 | 12.6 *i* |
| RT Librae | 15 0.8 | −18 21 | 10.0*d* | R Cassiop. | 53.3 | +50 50 | 9.6 |
| T Librae | 5.0 | −19 38 | 11.0*d* | Y Cassiop | 58.2 | +55 7 | 12.0 *i* |
| Y Librae | 6.4 | − 5 38 | 8.6 | SV Androm. | 59.2 | +39 33 | 13.0 |

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory. from observations made by the following observers:—T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, W. P. Hoge, S. C. Hunter, J. B. Lacchini. O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, C. B. Lindsley, D. B. Pickering, C. F. Richter, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young.

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**The Spectrum of Nova Geminorum No. 2, February 1916.**—A photograph of the spectrum of Nova Geminorum No. 2 taken on the nights of February 12 and 13 with a total exposure of nine hours shows that it has remained essentially unchanged during the past year. The spectrum is of the definite Wolf-Rayet type with bright hydrogen lines and an exceedingly prominent bright band at λ 4686. Several other Wolf-Rayet bands are present. The continuous spectrum is very strong.

WALTER S. ADAMS.
FRANCIS G. PEASE.

## Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of minima in 1916 May | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d | h | d | h | d | h | d | h |
| SY Androm. | 0 08.0 | +43 09 | 9.5—13.0 | 34 21.8 | | | 24 | 0 | | | | |
| RT Sculptor. | 31.5 | −26 13 | 9.6—10.5 | 0 12.3 | 3 | 22; | 11 | 14; | 19 | 7; | 26 | 23 |
| UU Androm. | 38.5 | +30 24 | 10.7—11.9 | 1 11.7 | 2 | 15; | 10 | 2; | 17 | 12; | 24 | 22 |
| U Cephei | 0 53.4 | +81 20 | 7.0— 9.0 | 2 11.8 | 6 | 10; | 13 | 21; | 21 | 9; | 28 | 20 |
| Z Persei | 2 33.7 | +41 46 | 9.4—12 | 3 01.4 | 7 | 17; | 13 | 20; | 19 | 23; | 26 | 2 |
| TW Cassiop. | 37.6 | +65 19 | 8.2— 9.0 | 1 10.3 | 6 | 13; | 13 | 17; | 20 | 20; | 28 | 0 |
| RY Persei | 39.0 | +47 43 | 8.0—10.3 | 6 20.7 | 5 | 14; | 12 | 11; | 19 | 8; | 26 | 5 |
| RZ Cassiop. | 39.9 | +69 13 | 6.9— 8.1 | 1 04.7 | 2 | 14; | 9 | 18; | 16 | 23; | 24 | 3 |
| TX Cassiop. | 44.4 | +62 22 | 9.4—10.1 | 2 22.2 | 9 | 1; | 17 | 19; | 26 | 14 | | |
| ST Persei | 53.7 | +38 47 | 8.5—10.5 | 2 15.6 | 6 | 7; | 14 | 6; | 22 | 5; | 30 | 4 |
| RX Cassiop. | 2 58.8 | +67 11 | 8.6— 9.1 | 32 07.6 | | | 17 | 5 | | | | |
| Algol | 3 01.7 | +40 34 | 2.3— 3.5 | 2 20.8 | 1 | 10; | 7 | 3; | 18 | 14; | 30 | 2 |
| RT Persei | 16.7 | +46 12 | 9.5—11.5 | 0 20.4 | 4 | 10; | 11 | 5; | 18 | 0; | 24 | 19 |
| λ Tauri | 55.1 | +12 12 | 3.3— 4.2 | 3 22.9 | 1 | 1; | 8 | 22; | 16 | 20; | 24 | 18 |
| RW Tauri | 3 57.8 | +27 51 | 7.1—<11 | 2 18.5 | 5 | 1; | 13 | 8; | 21 | 16; | 29 | 23 |
| RV Persei | 4 04.2 | +33 59 | 9.5—11.0 | 1 23.4 | 5 | 20; | 13 | 18; | 21 | 15; | 29 | 13 |
| RW Persei | 13.3 | +42 04 | 8.8—11.0 | 15 04.8 | | | 10 | 20; | 24 | 0 | | |
| SZ Tauri | 31.4 | +18 20 | 7.2— 7.7 | 3 03.6 | | | 10 | 3; | 19 | 13; | 29 | 0 |
| RS Cephei | 4 48.6 | +80 06 | 9.5—12.0 | 12 10.1 | 6 | 16; | 19 | 2; | 31 | 13 | | |
| TT Aurigae | 5 02.8 | +39 27 | 7.8— 8.7 | 0 16.0 | 1 | 1; | 14 | 9; | 21 | 1; | 27 | 17 |
| RY Aurigae | 11.5 | +38 13 | 10.7—11.7 | 2 17.5 | 2 | 6; | 7 | 17; | 18 | 15; | 29 | 13 |
| RZ Aurigae | 42.9 | +31 40 | 10.6—13.3 | 3 00.3 | 6 | 19; | 12 | 20; | 24 | 21; | 30 | 21 |
| SV Tauri | 45.8 | +28 05 | 9.4—11.0 | 2 04.0 | 4 | 22; | 13 | 14; | 22 | 6; | 30 | 22 |
| Z Orionis | 50.2 | +13 40 | 9.7—10.7 | 5 04.9 | 7 | 18; | 18 | 4; | 28 | 13 | | |
| SV Gemin. | 54.6 | +24 28 | 9.8—<11 | 4 00.2 | 2 | 12; | 10 | 3; | 18 | 13; | 26 | 13 |
| RW Gemin. | 5 55.4 | +23 08 | 9.5—11.0 | 2 20.8 | 3 | 15; | 9 | 9; | 20 | 20; | 26 | 13 |
| U Columbae | 6 11.2 | −33 03 | 9.2—10.0 | 2 19.2 | 3 | 19; | 15 | 0; | 20 | 15; | 26 | 5 |
| SX Gemin. | 22.0 | +20 37 | 10.8—11.5 | 1 08.8 | 4 | 17; | 12 | 22; | 21 | 2; | 29 | 7 |
| RW Monoc. | 29.3 | + 8 54 | 9.0—10.8 | 1 21.7 | 5 | 14; | 13 | 5; | 20 | 20; | 28 | 11 |
| RX Gemin. | 43.6 | +33 21 | 8.8— 9.6 | 12 05.0 | 1 | 11; | 13 | 16; | 25 | 21 | | |
| RU Monoc. | 6 49.4 | − 7 28 | 9.8—10.5 | 0 21.5 | 8 | 3; | 15 | 7; | 22 | 11; | 29 | 16 |
| R Can. Maj. | 7 14.9 | −16 12 | 5.8— 6.4 | 1 03.3 | 8 | 9; | 17 | 11; | 26 | 13 | | |
| RY Gemin. | 21.7 | +15 52 | 8.9—<10 | 9 07.2 | 7 | 12; | 16 | 19; | 26 | 2 | | |
| Y Camelop. | 27.6 | +76 17 | 9.5—12 | 3 07.3 | | | 12 | 22; | 22 | 20 | | |
| TX Gemin. | 30.3 | +17 8 | 10.0—11.9 | 2 19.2 | 6 | 19; | 15 | 5; | 23 | 14 | | |
| RR Puppis | 43.5 | −41 08 | 9.4—10.7 | 6 10.3 | 1 | 17; | 14 | 14; | 21 | 0; | 27 | 11 |
| V Puppis | 7 55.4 | −48 58 | 4.1— 4.8 | 1 10.9 | 7 | 20; | 15 | 3; | 22 | 9; | 29 | 16 |
| X Carinae | 8 29.1 | −58 53 | 7.9— 8.7 | 0 13.0 | 5 | 4; | 13 | 6; | 21 | 9; | 29 | 12 |
| S Cancri | 8 38.2 | +19 24 | 8.2—10 | 9 11.6 | | | 10 | 3; | 19 | 15; | 29 | 2 |
| RX Hydrae | 9 00.8 | − 7 52 | 9.1—10.5 | 2 6.8 | 8 | 7; | 17 | 10; | 26 | 13 | | |
| S Antliae | 27.9 | −28 11 | 6.7— 7.3 | 0 07.8 | 1 | 7; | 7 | 18; | 20 | 17; | 27 | 5 |
| S Velorum | 29.4 | −44 46 | 7.8— 9.3 | 5 22.4 | 6 | 8; | 12 | 6; | 24 | 3; | 30 | 2 |
| Y Leonis | 9 31.1 | +26 41 | 9.3—11.2 | 1 16.5 | 4 | 12; | 12 | 22; | 21 | 8; | 29 | 19 |
| RR Velorum | 10 17.8 | −41 36 | 10.0—10.9 | 1 20.5 | 8 | 12; | 17 | 18; | 27 | 1 | | |
| SS Carinae | 10 54.2 | −61 23 | 12.2—12.8 | 3 07.2 | 2 | 11; | 9 | 1; | 22 | 6; | 28 | 21 |
| ST Urs. Maj. | 11 22.4 | +45 44 | 6.7— 7.2 | 8 19.2 | 8 | 5; | 17 | 0; | 25 | 19 | | |
| RW Urs. Maj. | 35.4 | +52 34 | 10.3—11.4 | 7 07.9 | 4 | 0; | 11 | 8; | 18 | 16; | 26 | 0 |
| Z Draconis | 11 39.8 | +72 49 | 9.9—13.6 | 1 08.6 | 3 | 2; | 10 | 21; | 24 | 11; | 31 | 6 |
| RZ Centauri | 12 55.6 | −64 05 | 8.5— 8.9 | 1 21.0 | 5 | 7; | 13 | 19; | 21 | 7; | 28 | 19 |
| RS Can. Ven. | 13 06.3 | +36 28 | 7.5—12.5 | 4 19.2 | 4 | 8; | 13 | 22; | 23 | 12 | | |
| SS Centauri | 13 07.2 | −63 37 | 8.8—10.4 | 2 11.5 | 4 | 11; | 11 | 22; | 19 | 8; | 26 | 19 |
| δ Librae | 14 55.6 | − 8 07 | 4.8— 6.2 | 2 07.9 | 4 | 2; | 11 | 2; | 18 | 2; | 25 | 2 |

**Minima of Variable Stars of Short Period**—Continued.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of minima in 1916 May |
|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h d h d h d h d h |
| U Coronae | 15 14.1 | +32 01 | 7.6— 8.7 | 3 10.9 | 3 7; 10 5; 24 0; 30 22 |
| TW Draconis | 32.4 | +64 14 | 7.3— 8.9 | 2 19.4 | 2 3; 10 13; 18 23; 27 9 |
| SS Librae | 15 43.4 | −15 14 | 9.3—11.5 | 0 18.4 | 2 14; 10 6; 17 22; 25 13 |
| SW Ophiuchi | 16 11.1 | − 6 44 | 9.2—10.0 | 2 10.7 | 4 18; 12 2; 19 11; 26 19 |
| SX Ophiuchi | 12.6 | − 6 25 | 10.5—11.2 | 2 01.5 | 2 17; 10 23; 19 5; 27 11 |
| R Arae | 31.1 | −56 48 | 6.8— 7.9 | 4 10.2 | 6 8; 15 5; 24 1 |
| TT Herculis | 16 49.9 | +17 00 | 8.9— 9.3 | 20 18.1 | 2 21; 12 14; 23 14 |
| TU Herculis | 17 09.8 | +30 50 | 9.5—12 | 2 06.4 | 1 5; 8 0; 21 15; 28 10 |
| U Ophiuchi | 11.5 | + 1 19 | 6.0— 6.7 | 0 20.1 | 4 22; 13 7; 21 16; 30 1 |
| *u* Herculis | 13.6 | +33 12 | 4.6— 5.4 | 2 01.2 | 5 4; 11 8; 23 15; 29 19 |
| TX Herculis | 15.4 | +42 00 | 8.3— 9.0 | 1 00.7 | 2 0; 9 5; 23 15; 30 20 |
| RV Ophiuchi | 29.8 | + 7 19 | 9. —12 | 3 16.5 | 1 3; 8 12; 23 6; 30 15 |
| SZ Herculis | 36.0 | +33 01 | 9.5—10.3 | 0 19.6 | 6 10; 14 14; 22 18; 30 23 |
| TX Scorpii | 48.6 | −34 13 | 7.5— 8.2 | 0 22.6 | 5 20; 13 9; 20 22; 28 11 |
| UX Herculis | 49.7 | +16 57 | 8.8—10.5 | 1 13.2 | 2 10; 10 3; 17 22; 25 16 |
| Z Herculis | 53.6 | +15 09 | 7.1— 7.9 | 3 23.8 | 4 0; 12 0; 20 0; 27 23 |
| WX Sagittae | 53.6 | −17 24 | 9.2—10.8 | 2 03.1 | 2 20; 11 8; 19 21; 28 9 |
| WY Sagittae | 17 54.9 | −23 1 | 9.5—10.6 | 4 16.0 | 9 22; 19 6; 28 15 |
| SX Draconis | 18 03.0 | + 58 23 | 9.3—10.5 | 5 04.1 | 4 20; 15 4; 25 13 |
| RS Sagittarii | 11.0 | −34 08 | 5.9— 6.3 | 2 10.0 | 3 11; 10 17; 17 23; 25 5 |
| V Serpentis | 11.1 | −15 34 | 9.5—11.1 | 3 10.9 | 7 16; 14 13; 21 11; 28 9 |
| RZ Scuti | 21.1 | − 9 15 | 7.4— 8.3 | 15 03.2 | 2 4; 17 7 |
| RZ Draconis | 21.8 | +58 50 | 9.5—10.2 | 0 13.2 | 3 21; 12 4; 20 10; 28 16 |
| RX Herculis | 26.0 | +12 32 | 7.0— 7.6 | 0 21.3 | 3 5; 12 2; 20 23; 29 21 |
| SX Sagittarii | 39.7 | −30 36 | 8.7— 9.8 | 2 01.8 | 5 0; 13 7; 21 15; 29 22 |
| RR Draconis | 40.8 | +62 34 | 9.3—13 | 2 19.9 | 9 0; 17 12; 26 0 |
| RS Scuti | 43.7 | −10 21 | 9.3—10.3 | 0 15.9 | 7 12; 14 3; 20 19; 27 10 |
| *β* Lyrae | 46.4 | +33 15 | 3.4— 4.1 | 12 21.8 | 2 0; 14 22; 27 20 |
| U Scuti | 18 48.9 | −12 44 | 9.1— 9.6 | 0 22.9 | 6 23; 16 12; 26 1 |
| RX Draconis | 19 01.1 | +58 35 | 9.3—10.2 | 1 21.4 | 3 18; 11 8; 18 21; 26 11 |
| RV Lyrae | 12.5 | +32 15 | 11. —12.8 | 3 14.4 | 7 22; 15 3; 22 8; 29 13 |
| RS Vulpec. | 13.4 | +22 16 | 6.9— 8.0 | 4 11.4 | 7 9; 16 8; 25 7 |
| U Sagittae | 14.4 | +19 26 | 6.5— 9.0 | 3 09.1 | 3 16; 10 11; 23 23; 30 17 |
| Z Vulpec. | 17.5 | +25 23 | 7.3— 8.5 | 2 10.9 | 6 16; 14 1; 21 9; 28 18 |
| TT Lyrae | 24.3 | +41 30 | 9.3—11.6 | 5 05.8 | 2 8; 7 14; 18 2; 28 13 |
| UZ Draconis | 26.1 | +68 44 | 9.0— 9.8 | 1 15.1 | 7 9; 13 22; 20 11; 26 23 |
| SY Cygni | 19 42.7 | +32 28 | 10 —12 | 6 00.2 | 4 11; 10 11; 22 12; 28 12 |
| WW Cygni | 20 00.6 | +41 18 | 9.3—13.4 | 3 07.6 | 5 2; 11 18; 25 0; 31 16 |
| SW Cygni | 03.8 | +46 01 | 9. —11.7 | 4 13.8 | 4 22; 14 2; 23 5 |
| VW Cygni | 11.4 | +34 12 | 9.8—11.8 | 8 10.3 | 1 7; 9 18; 18 4; 26 14 |
| RW Capric. | 12.2 | −17 59 | 8.8—10.6 | 3 09.4 | 2 22; 9 17; 23 7; 30 2 |
| UW Cygni | 19.6 | +42 55 | 10.5—13 | 3 10.8 | 7 2; 14 0; 20 22; 27 19 |
| V Vulpec. | 32.3 | +26 15 | 8.2—9.8 | 37 19.0 | |
| W Delphini | 33.1 | +17 56 | 9.4—12.1 | 4 19.4 | 6 11; 16 1; 25 16 |
| RR Delphini | 38.9 | +13 35 | 10.5—11.8 | 4 14.4 | 4 23; 14 4; 23 9 |
| Y Cygni | 48.1 | +34 17 | 7.1— 7.9 | 1 12.0 | 7 14; 15 1; 22 13; 30 1 |
| WZ Cygni | 49.3 | +38 27 | 9.9—10.8 | 0 14.0 | 1 18; 13 11; 25 3; 30 23 |
| RR Vulpec. | 20 50.5 | +27 32 | 9.6—11.0 | 5 01.2 | 10 9; 20 11; 30 13 |
| VV Cygni | 21 02.3 | +45 23 | 12.1—13.8 | 1 11.4 | 1 9; 8 18; 23 12; 30 21 |
| AE Cygni | 09.0 | +30 20 | 10.8—11.4 | 0 23.3 | 2 12; 12 5; 21 22; 31 14 |
| RY Aquarii | 14.8 | −11 14 | 8.8—10.4 | 1 23.2 | 7 12; 15 8; 23 5; 31 2 |
| UZ Cygni | 55.2 | +43 52 | 8.9—11.6 | 31 07.3 | 18 20 |
| RT Lacertae | 21 57.4 | +43 24 | 9.1—10.5 | 5 01.7 | 2 20; 13 0; 23 3 |
| RW Lacertae | 22 40.6 | +49 08 | 10.2—11.2 | 5 04.4 | 1 9; 11 18; 22 3; 27 8 |
| X Lacertae | 22 45.0 | +55 54 | 8.2— 8.6 | 5 10.6 | 4 12; 15 9; 20 20; 31 17 |
| TT Androm. | 23 08.7 | +45 36 | 11.3—12.6 | 2 18.3 | 5 21; 14 4; 22 12; 30 19 |
| Y Piscium | 29.3 | + 7 22 | 9.0—12.0 | 3 18.4 | 3 18; 11 7; 18 19; 26 8 |
| TW Androm. | 23 58.2 | +32 17 | 8.6—11.5 | 4 02.9 | 3 1; 11 7; 19 13; 27 19 |

## Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of maxima in 1916. May | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h | d h | d h | d h | d h | d h | d h | d h |
| SX Cassiop. | 0 05.5 | +54 20 | 8.6— 9.4 | 36 13.7 | | | | | | | | |
| SY Cassiop. | 0 09.8 | +57 52 | 9.3— 9.9 | 4 1.7 | 4 11; | 12 14; | 20 18; | 28 21 | | | | |
| RR Ceti | 1 27.0 | + 0 50 | 8.3— 9.0 | 0 13.3 | 8 3; | 15 21; | 23 15; | 31 9 | | | | |
| RW Cassiop. | 1 30.7 | +57 15 | 8.9—11.0 | 14 19.2 | | 15 17; | 30 2 | | | | | |
| V Arietis | 2 09.6 | +11 46 | 8.3— 9.0 | 0 23.8 | 4 12; | 12 11; | 20 9; | 28 8 | | | | |
| SU Cassiop. | 2 43.0 | +68 28 | 6.5— 7.0 | 1 22.8 | 2 12; | 10 7; | 18 2; | 25 21 | | | | |
| TU Persei | 3 01.8 | +52 49 | 11.4—12.2 | 0 14.6 | 5 16; | 12 23; | 20 6; | 27 13 | | | | |
| RW Camelop. | 3 46.2 | +58 21 | 8.2— 9.4 | 16 00.0 | 9 | 25 | | | | | | |
| SX Persei | 4 10.2 | +41 27 | 10.4—11.2 | 4 07.0 | 1 20; | 10 10; | 19 0; | 27 14 | | | | |
| SV Persei | 42.8 | +42 07 | 8.8— 9.6 | 11 03.1 | 7 7; | 18 11; | 29 14 | | | | | |
| RX Aurigae | 4 54.5 | +39 49 | 7.2— 8.1 | 11 15.0 | 5 14; | 17 5; | 28 20 | | | | | |
| SX Aurigae | 5 04.6 | +42 02 | 8.0— 8.7 | 1 12.8 | 1 14; | 9 5; | 16 21; | 24 13 | | | | |
| SY Aurigae | 05.5 | +42 41 | 8.4— 9.5 | 10 03.3 | 2 0; | 12 3; | 22 7 | | | | | |
| Y Aurigae | 21.5 | +42 21 | 8.6— 9.6 | 3 20.6 | 1 8; | 9 1; | 16 18; | 24 11 | | | | |
| RZ Gemin. | 5 56.6 | +22 15 | 9.1—10.0 | 5 12.7 | 4 15; | 10 4; | 21 5; | 26 18 | | | | |
| RS Orionis | 6 16.5 | +14 44 | 8.2— 8.9 | 7 13.6 | 7 1; | 14 14; | 22 4; | 29 17 | | | | |
| T Monoc. | 19.8 | + 7 08 | 5.7— 6.8 | 27 00.3 | | 21 18 | | | | | | |
| RZ Camelop. | 23.7 | +67 06 | 11.0—13.0 | 0 11.5 | 4 3; | 11 8; | 18 3; | 25 18 | | | | |
| W Gemin. | 29.2 | +15 24 | 6.7— 7.5 | 7 22.0 | 8 9; | 16 7; | 24 5 | | | | | |
| ζ Gemin. | 6 58.2 | +20 43 | 3.7— 4.3 | 10 03.7 | 3 8; | 13 12; | 23 16 | | | | | |
| RU Camelop. | 7 10.9 | +69 51 | 8.5— 9.8 | 22 06.5 | | 21 1 | | | | | | |
| RR Gemin. | 7 15.2 | +31 04 | 10.0—11.5 | 0 09.5 | 2 20; | 10 19; | 18 17; | 26 16 | | | | |
| V Carinae | 8 26.7 | −59 47 | 7.4— 8.1 | 6 16.7 | 1 10; | 8 3; | 14 19; | 21 12 | | | | |
| T Velorum | 8 34.4 | −47 01 | 7.6— 8.5 | 4 15.3 | 4 19; | 14 2; | 23 8 | | | | | |
| V Velorum | 9 19.2 | −55 32 | 7.5— 8.2 | 4 08.9 | 8 7; | 17 1; | 25 19 | | | | | |
| Z Leonis | 9 46.4 | +27 22 | 7.9— 9.6 | 59 0.0 | | 27 | | | | | | |
| RR Leonis | 10 02.1 | +24 29 | 9.1—10.1 | 0 10.9 | 2 3; | 8 21; | 22 11; | 29 6 | | | | |
| SU Draconis | 11 32.2 | +67 53 | 8.9— 9.6 | 0 15.8 | 7 14; | 14 4; | 20 18; | 27 9 | | | | |
| S Muscae | 12 07.4 | −69 36 | 6.4— 7.3 | 9 15.8 | 3 13; | 13 5; | 22 21 | | | | | |
| SW Draconis | 12.8 | +70 04 | 8.8— 9.6 | 0 13.7 | 5 15; | 13 14; | 21 14; | 29 13 | | | | |
| T Crucis | 15.9 | −61 44 | 6.8— 7.6 | 6 17.6 | 2 8; | 9 1; | 22 12; | 29 7 | | | | |
| R Crucis | 18.1 | −61 04 | 6.8— 7.9 | 5 19.8 | 2 5; | 8 1; | 19 16; | 25 12 | | | | |
| S Crucis | 12 48.4 | −57 53 | 6.5— 7.6 | 4 16.6 | 3 19; | 13 4; | 22 13; | 31 23 | | | | |
| W Virginis | 13 20.9 | − 2 52 | 8.7—10.4 | 17 06.5 | | 14 9; | 31 15 | | | | | |
| SS Hydrae | 25.0 | −23 08 | 7.4— 8.1 | 8 4.8 | 2 19; | 11 0; | 19 5; | 27 10 | | | | |
| RV Urs. Maj. | 13 29.4 | +54 31 | 9.2— 9.9 | 0 11.2 | 1 17; | 8 18; | 22 19; | 29 19 | | | | |
| ST Virginis | 14 22.5 | − 0 27 | 10.3—11.4 | 0 09.9 | 8 9; | 16 14; | 24 19 | | | | | |
| V Centauri | 25.4 | −56 27 | 6.4— 7.8 | 5 11.9 | 2 11; | 13 10; | 18 22; | 29 22 | | | | |
| RS Bootis | 29.3 | +32 11 | 8.9—10.0 | 0 09.1 | 6 1; | 13 14; | 21 3; | 28 16 | | | | |
| RU Bootis | 14 41.5 | +23 44 | 12.8—14.3 | 0 11.9 | 2 15; | 10 1; | 17 11; | 24 21 | | | | |
| R Triang. Austr. | 15 10.8 | −66 08 | 6.7— 7.4 | 3 09.3 | 2 21; | 9 15; | 23 5; | 29 23 | | | | |
| S Triang. Austr. | 15 52.2 | −63 29 | 6.4— 7.4 | 6 07.8 | 2 2; | 8 10; | 21 2; | 27 9 | | | | |
| S Normae | 16 10.6 | −57 39 | 6.6— 7.6 | 9 18.1 | 4 5; | 14 0; | 23 18 | | | | | |
| RW Draconis | 33.7 | +58 03 | 9.6—10.8 | 0 10.6 | 2 15; | 11 2; | 19 22; | 28 19 | | | | |
| RV Scorpii | 16 51.8 | −33 27 | 6.7— 7.4 | 6 01.5 | 1 4; | 7 6; | 19 9; | 31 12 | | | | |
| X Sagittarii | 17 41.3 | −27 48 | 4.4— 5.0 | 7 00.3 | 3 0; | 10 0; | 24 1; | 31 1 | | | | |
| Y Ophiuchi | 47.3 | − 6 07 | 6.1— 6.5 | 17 02.9 | 2 22 | | 20 1 | | | | | |
| W Sagittarii | 17 58.6 | −29 35 | 4.3— 5.1 | 7 14.3 | 1 9; | 8 23; | 24 3; | 31 18 | | | | |
| Y Sagittarii | 18 15.5 | −18 54 | 5.4— 6.2 | 5 18.6 | 4 16; | 10 11; | 22 0; | 27 18 | | | | |
| U Sagittarii | 26.0 | −19 12 | 6.5— 7.3 | 6 17.9 | 1 2; | 7 20; | 21 8; | 28 2 | | | | |
| Y Scuti | 18 32.6 | − 8 27 | 8.7— 9.2 | 10 08.3 | | 10 2; | 20 11; | 30 19 | | | | |
| Y Lyrae | 34.2 | +43 52 | 11.3—12.3 | 0 12.1 | 6 6; | 12 7; | 24 9; | 30 9 | | | | |
| RZ Lyrae | 39.9 | +32 42 | 9.9—11.2 | 0 12.3 | 6 6; | 12 9; | 24 16; | 30 19 | | | | |

**Maxima of Variable Stars of Short Period**—Continued.

| Star | R.A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of maxima in 1916. May | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h | d h | d h | d h | d h | d h | d h | d h |
| RT Scuti | 18 44.1 | −10 30 | 9.1— 9.7 | 0 11.9 | 4 10; | 10 9; | 22 6; | 28 5 | | | | |
| κ Pavonis | 46.6 | −67 22 | 3.8— 5.2 | 9 02.2 | 9 11; | 18 13; | 27 15 | | | | | |
| U Aquilae | 19 24.0 | − 7 15 | 6.2— 6.9 | 7 00.6 | 3 3; | 10 3; | 24 4; | 31 5 | | | | |
| XZ Cygni | 30.4 | +56 10 | 8.6— 9.3 | 0 11.2 | 3 5; | 10 5; | 24 5; | 31 5 | | | | |
| U Vulpec. | 32.2 | +20 07 | 6.5— 7.6 | 7 23.5 | 7 6; | 15 6; | 23 6; | 31 5 | | | | |
| SU Cygni | 40.8 | +29 01 | 6.2— 7.0 | 3 20.3 | 2 12; | 10 4; | 17 21; | 25 13 | | | | |
| η Aquilae | 47.4 | + 0 45 | 3.7— 4.5 | 7 04.2 | 7 17; | 14 22; | 22 2; | 29 6 | | | | |
| S Sagittae | 51.5 | +16 22 | 5.6— 6.4 | 8 09.2 | 4 4; | 12 13; | 20 23; | 29 8 | | | | |
| X Vulpec. | 19 53.3 | +26 17 | 9.5—10.5 | 6 07.7 | 6 2; | 12 10; | 25 1; | 31 9 | | | | |
| X Cygni | 20 39.5 | +35 14 | 6.0— 7.0 | 16 09.3 | 4 16; | 21 1 | | | | | | |
| T Vulpec. | 47.2 | +27 52 | 5.5— 6.1 | 4 10.5 | 2 16; | 11 13; | 20 10; | 29 7 | | | | |
| WY Cygni | 52.3 | +30 03 | 9.6—10.4 | 0 13.5 | 3 3; | 16 14; | 23 8; | 30 1 | | | | |
| RV Capric. | 55.9 | −15 37 | 9.2—10.1 | 0 10.7 | 2 8; | 9 1; | 22 12; | 29 5 | | | | |
| TX Cygni | 20 56.4 | +42 12 | 8.5— 9.7 | 14 17.4 | 5 11; | 20 4 | | | | | | |
| VY Cygni | 21 00.4 | +39 34 | 8.8— 9.5 | 7 20.6 | 8 4; | 16 1; | 23 22; | 31 18 | | | | |
| SW Aquarii | 10.2 | − 0 20 | 9.9—10.8 | 0 11.0 | 4 12; | 11 10; | 18 7; | 25 4 | | | | |
| VZ Cygni | 21 47.7 | +42 40 | 8.2— 9.2 | 4 20.7 | 2 18; | 12 11; | 22 5; | 31 22 | | | | |
| Y Lacertae | 22 05.2 | +50 33 | 9.1— 9.6 | 4 07.8 | 5 14; | 14 5; | 22 22; | 31 13 | | | | |
| δ Cephei | 25.5 | +57 54 | 3.7— 4.6 | 5 08.8 | 1 17; | 12 11; | 23 4; | 28 13 | | | | |
| Z Lacertae | 36.9 | +56 18 | 8.2— 9.0 | 10 21.1 | 4 17; | 15 14; | 26 12 | | | | | |
| RR Lacertae | 37.5 | +55 55 | 8.5— 9.2 | 6 10.1 | 4 15; | 11 1; | 23 21; | 30 7 | | | | |
| V Lacertae | 22 44.5 | +55 48 | 8.5— 9.5 | 4 23.6 | 2 18; | 12 17; | 22 16; | 27 16 | | | | |
| SW Cassiop. | 23 03.7 | +58 11 | 9.2— 9.7 | 5 10.6 | 2 4; | 13 1; | 23 22; | 29 9 | | | | |
| RS Cassiop. | 32.6 | +61 52 | 9.0—11.0 | 6 07.1 | 7 1; | 13 8; | 19 15; | 25 22 | | | | |
| RY Cassiop. | 47.2 | +58 11 | 9.3—11.8 | 12 03.4 | 1 7; | 13 11; | 25 14 | | | | | |
| V Cephei | 23 51.7 | +82 38 | 6.0—7.0 | 0 23.6 | 2 11; | 12 10; | 22 10; | 27 9 | | | | |

**New Elements of V and X Lacertae.**—In the *Monthly Notices* of the Royal Astronomical Society for January 1916, Mr. C. Martin and Professor H. C. Plummer give the results of their study of the variables in Lacerta. The elements of maximum for V Lacertae

J. D. 2416666.76 + 4.98269 E,

determined at the Laws Observatory, are changed by these observations to

J. D. 2420050.456 + 4.983352 E.

The elements of minimum for X Lacertae

J. D. 2416672.45 + 5.44269 E,

also determined at the Laws Observatory, are changed to elements of maximum

J. D. 2419750.55 + 5.444442.

This new period is slightly longer than the former period used.

In this study the star B. D. + 55°2808 was selected as a comparison star, but it itself proved to be a variable. It has a variation of about a half a magnitude and is probably irregular.

The authors of this note express the opinion that about one in five of the stars in the the neighborhood of the ninth magnitude is variable to a measurable extent.

**The Colors of Fifteen Variables in M 3.**—We know from Bailey's work that in length of period and nature of light variation the variable stars in the globular cluster Messier 3 are closely similar to the short period Cepheids found outside the clusters. From recent measures of photographic and photovisual magnitudes it now appears that the spectra of these stars are also similar to the spectra of the non-cluster variables of analogous period. The following values, which indicate the color at or near maximum light, are given only to tenths since they are subject to some revision when the study of the cluster is completed.

| No. Var. | Photovisual Magnitude | Color Index | No. Var. | Photovisual Magnitude | Color Index |
|---|---|---|---|---|---|
| 22 | 15.2 | +0.2 | 71 | 15.2 | +0.1 |
| 43 | 15.2 | +0.1 | 85 | 15.3 | +0.0 |
| 44 | 15.3 | +0.2 | 98 | 15.3 | +0.2 |
| 56 | 15.3 | −0.2 | 99 | 15.2 | +0.1 |
| 61 | 15.1 | −0.1 | 107 | 15.2 | +0.3 |
| 65 | 14.9 | +0.0 | 121 | 15.1 | −0.2 |
| 70 | 15.2 | −0.0 | 128 | 15.2 | −0.1 |

The average photovisual magnitude at maximum is 15.20. The average color index is +0.05, corresponding to spectral type A1, which is practically identical with the average spectral type at maximum of the Cepheids with periods less than a day. If we assume that, in keeping with other Cepheids, the average absolute brightness of these variables in Messier 3 is not fainter than zero magnitude at maximum, then we derive at once that the parallax of the cluster is less than 0″.0001.

One of the brightest stars in the cluster, No. 95, is a variable of a totally different type. The range is small. Bailey was unable to determine the period and suggested that it might be an Algol variable. The new magnitude measures show the star to be very red; it may therefore be a variable of long or irregular period. Many such stars are known to be of high luminosity.

HARLOW SHAPLEY.

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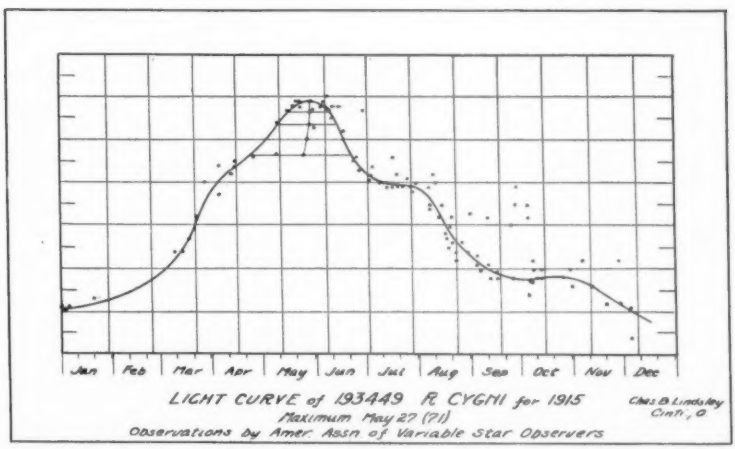

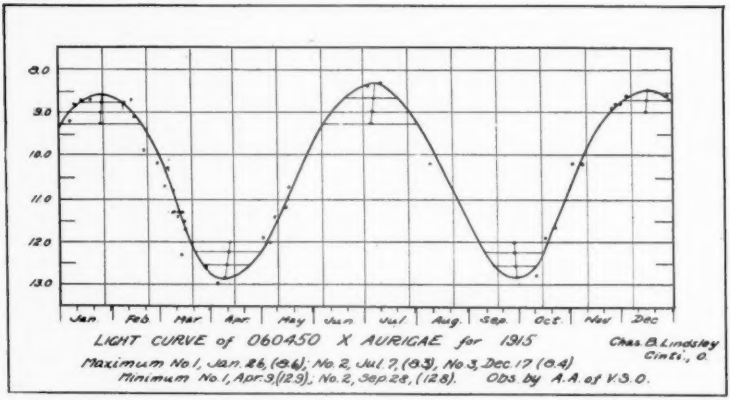


## COMET AND ASTEROID NOTES.

**Comet 1915 *e* (Taylor).**—Early in February Professor Barnard observed that this comet had developed a double nucleus. This comet is now very faint and consequently this interesting development can be observed only by means of the largest telescopes. Professor Barnard has made measures of the components as follows:

| | | | | | |
|---|---|---|---|---|---|
| 1916 Feb. | 9 | 14h 28m G. M. T. | P. A. | 21°.3 | Distance 9″,2 |
| | 26 | 13 44 " | " | 23 .3 | " 12 .1 |

The two parts seem to be separating slowly.

**New Comet Discovered by Neujmin.**—The first comet for the year 1916 was discovered by Neujmin at Simeis on February 24. It was of about the eleventh magnitude at the time of discovery and was moving south slowly. The following positions of this comet have been received to date through the Harvard College Observatory Bulletins.

| G.M.T. | R.A. h m s | Dec. ° ′ ″ | Observer | Place |
|---|---|---|---|---|
| Feb. 29.6120 | 8 58 46.28 | +13 35 18.2 | Van Biesbroeck | Yerkes Observatory |
| 29.7355 | 8 58 46.62 | 13 31 20.0 | Brown | Dearborn " |
| Mar. 3.4877 | 8 59 22.9 | 12 4 5 | Hartwig | Bamberg |
| 3.6745 | 8 59 26.84 | 11 58 12.9 | Van Biesbroeck | Yerkes Observatory |
| 3.6871 | 8 59 26.68 | 11 57 50.04 | Fox | Dearborn " |
| 4.5697 | 8 59 44.67 | 11 30 3.6 | Van Biesbroeck | Yerkes " |
| 4.600 | 8 59 43.80 | 11 29 28.03 | Pettit | Washburn College |
| 7.6585 | 9 1 3.5 | 9 53 20 | Aitken | Lick Observatory |
| 8.5666 | 9 1 32.26 | 9 25 8.2 | Van Biesbroeck | Yerkes " |

Two sets of elements have been received. The first by Castro at the Observatorio Nacional, Santiago, Chile, shows the comet to have been at perihelion on March 3; the second, by Miss Young and Messrs. Jeffers and Pierce at the University of California, shows the comet to have been at perihelion on March 11. The latter also gives 5.19 years at the period of the comet.

## NOTES FOR OBSERVERS.

### Monthly Report of the American Association of Variable Star Observers, Feb.-Mar., 1916.

Again unusually inclement and unfavorable meteorological conditions have greatly hindered our observational work and a meagre report results. Locally there were only eight clear days in the month of February, and there seems to have been a prevalence of fog on the Pacific coast.

We welcome two new members of the Association this month, Rev. C. S. Kathan, "K" of Aitken, Minn., who observes with a four-inch refractor, and R. A. Klahr, "Kl" of Colorado Springs, Colo.

Mr. Lacchini's report for last month arrived too late for publication, and is therefore included in this month's report.

Mr. S. C. Hunter is to be congratulated on his readable article, entitled "The Interest in Astronomy", published in the March issue of "The Guide to Nature." A print of his well-equipped observatory appears with the article.

Messrs. Eaton, McAteer, and Nolte deserve great credit for the many valuable early morning observations they contribute to this report.

The following calculated dates of maxima taken from "The Companion to the Observatory" are of interest:

| | | | | | |
|---|---|---|---|---|---|
| April 3 | 163266 | R Draconis | April 14 | 205923 | R Vulpeculae |
| 5 | 043274 | X Camelop | 18 | 043065 | T Camelop |
| 5 | 142584 | R Camelop | 20 | 065355 | R Lyncis |
| 6 | 021024 | R Arietis | 25 | 154615 | R Serpentis |
| 11 | 194048 | RT Cygni | | | |

Members of the Association are urged to spread the propaganda of Variable star observing as far as possible, and endeavor to secure new members for the Association. A variety of causes has resulted in a depletion of our list of active observers, and in order that a good monthly average of observations may be maintained it is necessary to increase the number of observers. Any articles concerning variable star observing that our members can publish in the Press and other publications, will go far to advertise the practical nature of the work in which we are engaged, and attract recruits to our ranks.

The following members contributed to this report:—Messrs. Bouton, Burbeck, Eaton, Hoge, Hunter, Lacchini, Lindsley, Mach, McAteer, Mundt, Nolte, Pickering, Richter, Vrooman, Miss Swartz and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Mar. 10, 1916.

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1916.

001046
X Androm.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 21 | 11.0 | V |
| | 28 | 9.9 | B |

001755
T Cassiop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 28 | 9.0 | R |
| 2 | 3 | 8.9 | Bu |
| | 4 | 9.1 | Nt |
| | 14 | 8.6 | S |
| | 15 | 8.4 | B |
| | 21 | 8.7 | M |
| | 28 | 8.6 | S |

*001909*
S Ceti

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 10.4 | Bu |

003179
X Cephei

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 7 | 11.0 | Hu |

004435
V Androm.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 4 | 11.5 | Nt |

004958
W Cassiop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 28 | 9.7 | B |
| | 29 | 10.8 | M |

010940
U Androm.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 9 | 12.0 | Hu |

*011208*
S Piscium

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 9.6 | Bu |

011712
U Piscium

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 10.2 | Bu |

012502
R Piscium

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 28 | 10.8 | R |

014958
X Cassiop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 7 | 11.1 | Y |
| | 28 | 10.3 | B |
| | 29 | 10.6 | M |

015254
U Persei

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 28 | 8.5 | R |
| 2 | 3 | 7.8 | Bu |
| | 7 | 8.0 | Hu |
| | 21 | 8.4 | V |
| | 29 | 8.2 | M |

015912
S Arietis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 22 | 12.9 | B |

021024
R Arietis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 10.2 | Bu |
| | 14 | 9.3 | R |
| | 14 | 9.5 | S |
| | 28 | 8.4 | S |

*021403*
*o* Ceti

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 12 | 21 | 2.8 | L |
| 1 | 10 | 3.1 | L |
| | 14 | 3.4 | L |
| | 16 | 3.4 | L |
| | 24 | 3.5 | L |
| | 28.6 | 3.9 | R |
| | 29.6 | 3.9 | R |
| | 30 | 3.6 | L |
| | 30.6 | 4.0 | R |
| | 31 | 4.1 | E |
| | 31.6 | 4.0 | R |
| | 31 | 4.1 | Mu |
| 2 | 1 | 4.1 | E |
| | 1 | 4.1 | Ma |
| | 2 | 4.1 | E |
| | 3 | 4.2 | E |
| | 3 | 4.2 | Bu |
| | 3 | 4.4 | Pi |
| | 3.5 | 4.4 | Nt |
| | 5 | 4.2 | Ly |
| | 5.6 | 4.2 | R |
| | 6.6 | 4.4 | R |
| | 7 | 4.2 | E |
| | 7 | 3.9 | Ma |
| | 7.5 | 4.5 | Nt |
| | 9.5 | 4.3 | Ly |
| | 10.5 | 4.6 | Nt |
| | 11 | 4.1 | L |
| | 13 | 4.5 | E |
| | 13 | 4.4 | L |
| | 14.5 | 4.6 | Nt |
| | 14.6 | 4.6 | R |
| | 14 | 4.4 | L |
| | 21.5 | 4.8 | Nt |
| | 21.6 | 4.9 | R |
| | 26.6 | 5.2 | Nt |
| | 29.5 | 5.2 | Nt |

021658
S Persei

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 28 | 9.6 | R |
| 2 | 3 | 8.8 | Bu |

*022000*
R Ceti

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 28 | 8.7 | R |
| 2 | 3 | 8.6 | Bu |

023133
R Triang.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 29 | 6.8 | R |
| 2 | 3 | 7.2 | Bu |
| | 9 | 6.7 | Hu |

024356
W Persei

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 29 | 10.8 | R |
| 2 | 3 | 10.2 | Bu |
| | 9 | 10.0 | Hu |
| | 29 | 10.0 | M |

030514
U Arietis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 7 | 11.0 | Y |

032043
Y Persei

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 29 | 10.0 | R |
| 2 | 3 | 9.6 | Bu |
| | 9 | 10.0 | Hu |
| | 29 | 10.0 | M |

033362
U Camelop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 29 | 8.7 | R |

*035124*
T Eridani

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 31 | 7.5 | Ho |

*035915*
V Eridani

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 9.0 | R |
| | 31 | 9.0 | Pi |
| | 31 | 9.0 | Ho |

042215
W Tauri

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 8.7 | R |
| | 31 | 10.1 | Pi |
| 2 | 3 | 9.5 | Bu |
| | 4 | 9.7 | Nt |
| | 5 | 9.6 | Ly |
| | 9 | 9.4 | Hu |
| | 21 | 9.2 | M |
| | 29 | 10.0 | Pi |

043065
T Camelop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 9.6 | Bu |

043208
RX Tauri

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 11.1 | R |
| 2 | 3 | 10.6 | Pi |
| | 3 | 10.4 | E |
| | 7 | 10.6 | Y |
| | 9 | 10.3 | Hu |
| | 29 | 11.4 | B |

043274
X Camelop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 14 | 10.3 | L |

044617
V Tauri

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 10.8 | R |
| 2 | 4 | 11.7 | Nt |
| | 7 | 12.4 | Y |

*045307*
R Orionis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 7 | 11.6 | Y |
| | 10 | 11.0 | B |

*045514*
R Leporis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 10 | 8.9 | L |
| | 16 | 8.2 | L |
| | 30 | 8.7 | R |
| | 31 | 8.8 | Ho |
| 2 | 3 | 8.1 | Bu |
| | 3 | 9.0 | Pi |
| | 13 | 8.5 | L |
| | 14 | 9.3 | L |
| | 29 | 9.3 | M |

*050022*
T Leporis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 9.2 | R |
| | 31 | 9.0 | Ho |
| 2 | 3 | 9.5 | Bu |
| | 3 | 9.5 | Pi |

050003
V Orionis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 9.8 | Bu |
| | 3 | 9.5 | B |
| | 4 | 9.9 | B |
| | 29 | 11.4 | B |
| | 29 | 11.2 | Pi |

052034
S Aurigae

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 9.2 | Bu |
| | 6 | 9.8 | L |

*052404*
S Orionis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 31 | 10.0 | Ho |
| 2 | 3 | 10.2 | Bu |
| | 10 | 9.5 | B |

*053005*
T Orionis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 10 | 9.2 | L |
| | 31 | 9.6 | Ho |
| 2 | 3 | 10.2 | Bu |
| | 3 | 9.5 | Pi |
| | 3 | 9.6 | Nt |
| | 5 | 10.3 | Ly |
| | 10 | 9.5 | B |
| | 19 | 9.2 | Ho |
| | 28 | 9.6 | Pi |

054319
SU Tauri

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 3 | 9.6 | Bu |
| | 3 | 9.5 | V |
| | 3.5 | 9.7 | E |
| | 4.5 | 9.5 | B |
| | 7 | 9.7 | Y |
| | 7.5 | 9.5 | E |

SU Tauri

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 2 | 10.5 | 9.6 | B |
| | 21 | 9.4 | V |
| | 22.5 | 9.6 | B |
| | 23.7 | 9.6 | E |
| | 27 | 9.4 | V |

054920
U Orionis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 10 | 11.6 | L |
| | 31 | 10.8 | E |
| 2 | 7 | 11.2 | Pi |
| | 7 | 10.8 | Y |
| | 21 | 10.5 | M |
| | 25 | 10.9 | Hu |

054974
V Camelop.

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 31 | 10.2 | E |
| 2 | 1 | 9.7 | E |
| | 2 | 9.9 | E |
| | 3 | 10.0 | Bu |
| | 3 | 9.8 | V |
| | 3 | 10.0 | E |
| | 7 | 10.4 | E |
| | 21 | 11.0 | V |
| | 23 | 11.0 | E |
| | 27 | 11.0 | V |

*060124*
S Leporis

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30 | 6.2 | R |
| | 31 | 6.5 | Ho |

060450
X Aurigae

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 10 | 10.0 | L |
| | 26 | 10.3 | L |
| 2 | 6 | 11.7 | L |
| | 28 | 13.6 | B |

060547
SS Aurigae

| Mo. | Day | Est | Obs. |
|---|---|---|---|
| 1 | 30.3 | 10.5 | L |
| | 31.6 | 10.3 | R |
| | 31.7 | 10.4 | E |
| 2 | 1.5 | 10.5 | B |
| | 1.6 | 10.6 | E |
| | 2.5 | 10.5 | E |
| | 3.5 | 10.6 | Pi |
| | 3.5 | 10.5 | M |
| | 3.5 | 10.7 | E |
| | 3 | 10.7 | V |
| | 3 | 10.4 | Bu |
| | 4.5 | 11.1 | B |
| | 5.2 | 10.6 | L |
| | 5.6 | 11.0 | R |
| | 6.2 | 10.6 | L |

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1916—Continued.

SS Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 2 | 6.6 | 11.2 | R |
| | 7.3 | 11.1 | L |
| | 7.5 | 11.1 | E |
| | 9.7 | 12.6 | E |
| | 10.5 | 12.8 | B |

061647
V Aurigae

| | | | |
|---|---|---|---|
| 2 | 3 | 9.6 | Bu |

*061702*
V Monoc.

| | | | |
|---|---|---|---|
| 1 | 31 | 7.7 | Ho |
| 2 | 3 | 7.8 | Bu |
| | 4 | 7.9 | Pi |
| | 21 | 8.8 | M |
| | 29 | 9.0 | Pi |

065111
Y Monoc.

| | | | |
|---|---|---|---|
| 2 | 1 | 11.7 | E |

*065208*
X Monoc.

| | | | |
|---|---|---|---|
| 1 | 10 | 8.6 | L |
| | 31 | 9.7 | R |
| | 31 | 8.6 | Ho |
| 2 | 3 | 8.3 | M |
| | 3 | 8.7 | Bu |
| | 4 | 8.8 | Pi |
| | 7 | 8.5 | Pi |
| | 29 | 7.4 | Pi |

065355
R Lyncis

| | | | |
|---|---|---|---|
| 1 | 31 | 9.1 | R |
| 2 | 3 | 9.4 | Bu |

070122a
R Gemin.

| | | | |
|---|---|---|---|
| 1 | 31 | 11.2 | R |
| 2 | 3 | 10.2 | Pi |
| | 3 | 10.3 | Nt |
| | 21 | 11.3 | M |

070122
TW Gemin.

| | | | |
|---|---|---|---|
| 1 | 31 | 8.6 | R |
| 2 | 3 | 8.4 | Pi |
| | 3 | 8.4 | Nt |
| | 21 | 8.8 | M |

070122b
Z Gemin.

| | | | |
|---|---|---|---|
| 2 | 3 | 12.3 | Nt |

070310
R Can. Min.

| | | | |
|---|---|---|---|
| 1 | 10 | 10.8 | L |
| 2 | 7 | 10.6 | Pi |
| | 14 | 9.9 | B |
| | 29 | 10.4 | Pi |

072708
S Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 1 | 10 | 7.8 | L |
| | 16 | 8.1 | L |
| | 31 | 7.6 | Mu |
| | 31 | 8.3 | R |
| 2 | 1 | 8.5 | E |
| | 3 | 8.4 | Bu |
| | 3 | 8.4 | Pi |
| | 7 | 8.8 | Ly |
| | 7 | 8.6 | Pi |
| | 13 | 8.8 | L |
| | 14 | 8.8 | S |
| | 21 | 9.0 | M |
| | 28 | 9.4 | Pi |

072811
T Can. Min.

| | | | |
|---|---|---|---|
| 2 | 1 | 12.3 | E |
| | 22 | 13.7 | B |

073508
U Can. Min.

| | | | |
|---|---|---|---|
| 1 | 10 | 9.3 | L |
| | 30 | 8.7 | L |
| 2 | 3 | 8.2 | Bu |
| | 7 | 8.3 | Pi |
| | 13 | 8.9 | L |
| | 14 | 8.5 | B |
| | 21 | 8.8 | M |

073723
S Gemin.

| | | | |
|---|---|---|---|
| 2 | 28 | 13.8 | B |

074323
T Gemin.

| | | | |
|---|---|---|---|
| 2 | 1 | 12.5 | E |

074922
U Gemin.

| | | | |
|---|---|---|---|
| 2 | 4.5 | 13.9 | B |

081112
R Cancri

| | | | |
|---|---|---|---|
| 1 | 10 | 10.2 | L |
| 2 | 5 | 9.8 | R |
| | 10 | 9.1 | B |
| | 11 | 9.3 | L |
| | 15 | 9.0 | Bu |
| | 23 | 9.1 | E |
| | 29 | 9.2 | Pi |

081617
V Cancri

| | | | |
|---|---|---|---|
| 1 | 31 | 8.4 | E |
| 2 | 5 | 8.3 | R |
| | 29 | 8.2 | Pi |

*082405*
RT Hydrae

| | | | |
|---|---|---|---|
| 1 | 10 | 8.4 | L |

083019
U Cancri

| | | | |
|---|---|---|---|
| 2 | 2 | 12.7 | E |

084803
S Hydrae

| | | | |
|---|---|---|---|
| 1 | 31 | 9.6 | E |
| 2 | 7 | 9.6 | Pi |
| | 14 | 10.1 | R |
| | 15 | 8.9 | Bu |
| | 28 | 11.2 | Pi |

*085008*
T Hydrae

| | | | |
|---|---|---|---|
| 2 | 15 | 9.4 | Bu |
| | 23 | 9.7 | E |

085120
T Cancri

| | | | |
|---|---|---|---|
| 1 | 14 | 9.5 | L |

090151
V Urs. Maj.

| | | | |
|---|---|---|---|
| 1 | 16 | 10.2 | L |
| | 28 | 10.2 | R |
| | 28 | 10.0 | R |
| | 30 | 10.0 | R |
| | 31 | 10.8 | R |
| | 31 | 10.4 | Pi |
| 2 | 3 | 10.2 | M |
| | 5 | 10.0 | R |
| | 6 | 10.3 | R |
| | 10 | 10.5 | B |
| | 21 | 10.3 | V |
| | 21 | 10.4 | R |
| | 22 | 10.7 | Mu |

*093014*
X Hydrae

| | | | |
|---|---|---|---|
| 1 | 31 | 9.7 | E |
| 2 | 15 | 9.2 | Bu |
| | 29 | 8.6 | Pi |

093934
R Leo. Min.

| | | | |
|---|---|---|---|
| 1 | 31 | 7.4 | E |
| 2 | 3 | 7.5 | M |
| | 3 | 7.1 | Pi |
| | 14 | 7.5 | S |
| | 15 | 7.0 | Bu |
| | 28 | 8.1 | S |
| | 29 | 7.7 | Hu |

094211
R Leonis

| | | | |
|---|---|---|---|
| 1 | 10 | 6.4 | L |
| | 16 | 6.9 | L |
| 2 | 7 | 8.2 | Pi |
| | 7 | 7.7 | Ly |
| | 11 | 8.2 | L |
| | 13 | 7.7 | M |
| | 14 | 8.2 | S |
| | 14 | 8.4 | R |
| | 15 | 7.9 | B |
| | 22 | 8.7 | Mu |

*094622*
Y Hydrae

| | | | |
|---|---|---|---|
| 2 | 15 | 7.0 | Bu |
| | 29 | 6.8 | Pi |

095421
V Leonis

| | | | |
|---|---|---|---|
| 2 | 22 | 12.8 | Y |
| | 29 | 13.2 | B |

*103212*
U Hydrae

| | | | |
|---|---|---|---|
| 1 | 10 | 5.1 | L |

103769
R Urs. Maj.

| | | | |
|---|---|---|---|
| 1 | 31 | 8.3 | Pi |
| 2 | 3 | 8.5 | M |
| | 13 | 8.9 | M |
| | 14 | 8.9 | S |
| | 14 | 9.1 | R |
| | 15 | 8.6 | B |
| | 21 | 9.5 | Bu |
| | 21 | 9.6 | M |
| | 28 | 9.7 | S |
| | 28 | 9.7 | Pi |
| | 29 | 10.0 | M |

*104620*
V Hydrae

| | | | |
|---|---|---|---|
| 1 | 10 | 6.3 | L |
| 2 | 21 | 7.4 | Bu |
| | 29 | 7.0 | Pi |

104814
W Leonis

| | | | |
|---|---|---|---|
| 2 | 22 | 12.5 | Y |
| | 29 | 12.8 | B |

*121418*
R Corvi

| | | | |
|---|---|---|---|
| 2 | 1 | 10.0 | Ho |
| | 13 | 9.3 | M |

122532
T Can. Ven.

| | | | |
|---|---|---|---|
| 2 | 29 | 10.6 | Pi |

122803
Y Virginis

| | | | |
|---|---|---|---|
| 2 | 1 | 9.0 | Ho |
| | 13 | 9.6 | M |

123160
T Urs. Maj.

| | | | |
|---|---|---|---|
| 2 | 28 | 12.7 | B |

123307
R Virginis

| | | | |
|---|---|---|---|
| 1 | 14 | 6.3 | L |
| 2 | 12 | 7.6 | L |
| | 13 | 8.0 | M |

123459
RS Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 1 | 31 | 10.9 | Pi |
| 2 | 7 | 11.0 | Pi |
| | 13 | 11.2 | M |

123961
S Urs. Maj.

| | | | |
|---|---|---|---|
| 1 | 16 | 7.9 | L |
| | 31 | 8.3 | Pi |
| 2 | 1 | 8.0 | E |
| | 3 | 8.3 | M |
| | 4 | 7.9 | Pi |
| | 12 | 8.0 | L |
| | 13 | 8.0 | M |
| | 14 | 7.7 | R |
| | 15 | 8.0 | B |
| | 21 | 7.8 | Bu |
| | 28 | 8.5 | S |

*132422*
R Hydrae

| | | | |
|---|---|---|---|
| 1 | 10 | 9.2 | L |
| 2 | 12 | 8.1 | L |

*132706*
S Virginis

| | | | |
|---|---|---|---|
| 1 | 10 | 7.7 | L |
| | 16 | 7.6 | L |
| 2 | 1 | 7.8 | Ho |
| | 12 | 8.0 | L |
| | 13 | 8.4 | M |

134440
R Can. Ven.

| | | | |
|---|---|---|---|
| 1 | 10 | 7.5 | L |
| | 31 | 8.2 | E |
| 2 | 13 | 8.3 | M |
| | 21 | 7.3 | Bu |
| | 28 | 8.4 | Pi |

141567
U Urs. Min.

| | | | |
|---|---|---|---|
| 2 | 14 | 8.7 | S |
| | 21 | 8.8 | Bu |
| | 28 | 8.8 | S |
| | 28 | 9.0 | Pi |
| | 29 | 9.0 | B |

141954
S Bootis

| | | | |
|---|---|---|---|
| 1 | 31 | 12.8 | E |

142539
V Bootis

| | | | |
|---|---|---|---|
| 1 | 10 | 9.4 | L |
| 2 | 13 | 9.3 | M |
| | 29 | 9.9 | Pi |

142584
R Camelop.

| | | | |
|---|---|---|---|
| 2 | 29 | 10.6 | B |

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1916—Continued.

143227
R Bootis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 1 | 10 | 9.2 | L |
| | 16 | 9.3 | L |

*150018*
RT Librae

| | | | |
|---|---|---|---|
| 2 | 1 | 9.6 | Ho |

*150519*
T Librae

| | | | |
|---|---|---|---|
| 2 | 1 | 10.8 | Ho |

*150605*
Y Librae

| | | | |
|---|---|---|---|
| 1 | 14 | 9.3 | L |
| 2 | 12 | 8.8 | L |

*151520*
S Librae

| | | | |
|---|---|---|---|
| 1 | 14 | 8.5 | L |
| 2 | 12 | 8.7 | L |

153378
S Urs. Min.

| | | | |
|---|---|---|---|
| 1 | 14 | 10.8 | L |
| 2 | 4 | 9.9 | B |
| | 7 | 9.6 | Ly |
| | 14 | 10.4 | L |
| | 21 | 9.6 | Bu |
| | 21 | 10.4 | R |
| | 28 | 10.2 | Pi |

154428
R Cor. Bor.

| | | | |
|---|---|---|---|
| 1 | 10 | 6.4 | L |
| | 14 | 6.7 | L |
| 2 | 7.9 | 6.2 | Nt |
| | 12.7 | 6.3 | L |
| | 13.9 | 6.0 | M |
| | 14.7 | 6.3 | L |
| | 15.9 | 6.2 | Nt |

R Cor. Bor.

| | | | |
|---|---|---|---|
| 2 | 26.6 | 6.0 | Nt |
| | 28.7 | 6.1 | Nt |
| | 29.6 | 6.1 | Nt |
| | 29.9 | 5.9 | M |

155847
X Herculis

| | | | |
|---|---|---|---|
| 2 | 7 | 6.1 | Nt |
| | 15 | 6.5 | Nt |
| | 28 | 7.1 | Nt |

*162112*
V Ophiuchi

| | | | |
|---|---|---|---|
| 2 | 1 | 7.8 | Ho |

162119
U Herculis

| | | | |
|---|---|---|---|
| 2 | 29 | 11.2 | M |

162807
SS Herculis

| | | | |
|---|---|---|---|
| 1 | 10 | 11.5 | L |
| 2 | 12 | 10.9 | L |

163172
R Urs. Min.

| | | | |
|---|---|---|---|
| 2 | 13 | 10.4 | M |
| | 21 | 9.9 | R |
| | 23 | 10.5 | E |
| | 29 | 9.6 | B |

163266
R Draconis

| | | | |
|---|---|---|---|
| 2 | 13 | 9.7 | M |

*164319*
RR Ophiuchi

| | | | |
|---|---|---|---|
| 2 | 1 | 8.6 | Ho |

165631
RV Herculis

| | | | |
|---|---|---|---|
| 2 | 29 | 11.3 | M |

*184205*
R Scuti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 2 | 7.9 | 5.8 | Nt |
| | 12.7 | 6.3 | L |
| | 14.7 | 6.1 | L |

193732
TT Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 8.2 | L |
| | 24 | 8.0 | L |

194632
χ Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 5.1 | L |
| | 24 | 5.5 | L |

200647
SV Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 9.3 | L |
| 2 | 3 | 9.4 | M |

200938
RS Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 8.0 | L |
| | 24 | 8.2 | L |

201647
U Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 7.3 | L |
| | 30 | 7.6 | R |
| 2 | 3 | 7.2 | M |

202946
SZ Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 10.0 | L |
| | 24 | 9.3 | L |
| | 27 | 10.5 | R |
| | 30 | 9.9 | L |
| 2 | 7 | 9.3 | L |
| | 14 | 10.0 | L |

203847
V Cygni

| | | | |
|---|---|---|---|
| 2 | 3 | 10.3 | M |

210868
T Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 1 | 10 | 6.5 | L |
| | 28 | 8.0 | R |
| | 30 | 6.9 | L |
| 2 | 7 | 7.8 | Nt |
| | 14 | 8.1 | L |
| | 26 | 7.7 | Nt |

213244
W Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 5.8 | L |
| | 16 | 5.8 | L |
| | 24 | 5.6 | L |
| | 26 | 5.8 | L |
| | 28 | 6.3 | R |
| 2 | 6 | 5.7 | L |
| | 13 | 5.8 | L |
| | 14 | 5.7 | L |

213753
RU Cygni

| | | | |
|---|---|---|---|
| 2 | 3 | 8.9 | M |

213843
SS Cygni

| | | | |
|---|---|---|---|
| 1 | 14.2 | 11.8 | L |
| | 16.3 | 11.8 | L |
| | 24.2 | 11.8 | L |
| | 26.2 | 11.8 | L |
| | 30.2 | 11.8 | L |
| 2 | 1.5 | 9.0 | B |
| | 3.3 | 9.3 | V |
| | 3.5 | 9.5 | M |
| | 3.5 | 9.6 | B |
| | 3.5 | 9.5 | Nt |
| | 4.5 | 9.9 | B |
| | 4.5 | 9.5 | Nt |
| | 5.2 | 10.0 | L |
| | 6.3 | 11.0 | L |
| | 7.3 | 11.1 | L |
| | 7.5 | 10.6 | Ly |
| | 7.5 | 11.0 | Nt |

SS Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| | 10.5 | 11.5 | B |
| | 10.5 | 11.7 | Nt |
| | 11.3 | 11.2 | L |
| | 12.8 | 11.3 | L |
| | 14.7 | 11.5 | L |
| | 21.5 | 11.7 | B |
| | 29.5 | 11.8 | B |

213937
RV Cygni

| | | | |
|---|---|---|---|
| 1 | 14 | 7.0 | L |
| | 24 | 7.9 | L |

222439
S Lacertae

| | | | |
|---|---|---|---|
| 2 | 7 | 12.7 | Y |

223841
R Lacertae

| | | | |
|---|---|---|---|
| 2 | 7 | 12.1 | Y |

230110
R Pegasi

| | | | |
|---|---|---|---|
| 1 | 28 | 8.7 | R |
| 2 | 7 | 8.4 | Nt |

230759
V Cassiop.

| | | | |
|---|---|---|---|
| 2 | 7 | 12.1 | Y |

233335
ST Androm.

| | | | |
|---|---|---|---|
| 2 | 3 | 10.3 | B |
| | 28 | 9.6 | S |

235350
R Cassiop.

| | | | |
|---|---|---|---|
| 1 | 28 | 9.2 | R |

No. of observations 431; No. of stars observed 121; No. of observers 16.

## COMMUNICATIONS.

**Trails of Venus and Jupiter.**—The accompanying photograph of Venus and Jupiter was made with a rapid rectilinear lens of 6½ inch focus with a clear opening of 13/16 inches, just the ordinary lens that is furnished with a good hand camera. The exposure was from 6:31 to 6:36 P. M., E. S. T., February 14, 1916. The sun had set nearly an hour previously, but a little of the sunset glow is still visible. The moon was eleven days old and its light can be seen reflected from the roof of the house on the left. The position of the camera was in longitude 75° 23′ 7″.8, and latitude N 40° 3′ 3″.4. This location had been carefully calculated as an exercise from observations of the occultation of Aldebaran, December 12, 1904.

The difference in Right Ascension of the two planets was $0^h\ 3^m\ 2^s.67$ sec., and in declination, 0° 5′ 49″, making the actual angular distance between them 0° 46′ 2″, or approximately 1½ times the diameter of the full moon. As the length

of the exposure was exactly five minutes the trails are 1¼° long; the change in position of the planets due to their orbital motion being too small to take into consideration. For Venus this change for the given five minutes was less than 10″ (9.962″) in Right Ascension, and for Jupiter about 1/60 as much (0.166″).

24 hours earlier the planets were within 25′ of each other, but while they were visible the atmosphere was too hazy to attempt a photograph. Although the planets look so close together it is interesting to remember that the distance between them is several times greater than from us to Venus, Jupiter being several hundred million miles beyond the brighter but smaller planet.

HENRY G. BLATCHLEY.

401 Chestnut Lane, Wayne, Pa.

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**Peculiar Disappearance of Jupiter's Satellite, III.**—Some time since I saw a rather curious and rare occurrence, which, while it may have little or no significance, I think is worth giving an account of.

On December 1, 1915, at 8 hrs. 37 min. C. S. T., the aspect of Jupiter and his satellites was about as on the inclosed sketch. The distance from III to Jupiter was estimated by eye to be about 3½ diameters of the planet, which would make it about 140″, and from II to III was about 15″ to 20″.

Within a very few seconds of 8 hrs. 37 min. 15 sec. C. S. T., as the satellites were being watched with 300 power on our five-inch refractor, with Jupiter himself

in the field, III entirely or almost entirely winked out. II and Jupiter were not affected. The disappearance and reappearance seemed gradual, and extended over a space of at least half a second: more probably 3/5 or 3/4 second—much longer than it takes to wink the eye. The seeing was very good—9 on my scale.

The question as to whether the disappearance and reappearance were actually gradual is very important. I have since experimented with the occultation of an artificial star, and I found that the disappearance had a tendency to seem gradual; and it was the disappearance which most certainly seemed gradual in the phenomenon observed; yet I know that the instant the thing happened, the apparent leisureliness of it was the most striking feature—the air of deliberation and matter-of-fact-ness. I can still, twenty days after, picture the occurrence to my mind.

When one comes to inquire into the cause, a bird at once suggests itself. But with a bird, the occultation would have lasted only so long as it would have taken him to traverse a cylinder five inches in diameter, and at the speed that birds fly, the time would hardly have been long enough to make itself felt over persistence of vision, unless indeed the bird happened to be flying right along the line of sight, or nearly so, which is improbable. More than that, I do not know whether birds are accustomed to flying at that time of night and year, that is, except owls. But this bird must have been at a considerable distance from the telescope in order to avoid occulting II, for an angle of 20″ makes an arc of less than 1.2 inches, even at 1000 ft. distance, and I believe the owl flies low.

But if one, to avoid the improbabilities noted above, turns to occultation by some kind of a body in interplanetary space, the question arises, how could a body large enough to make an occultation lasting as long as that seen, escape being itself seen? For anything that intercepts light usually reflects light.

Altogether the incident seems very curious, and it would be interesting to know whether any others have seen anything similar. I have heard mention of mysterious occultations of stars, but I have never seen an account of one, and I think they are usually ascribed to birds.

The above account is written from full notes made within a few minutes of the occultation, while the facts were still very vivid in my mind.

O. H. Truman.

Iowa City, Iowa.

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**The Aurora Borealis of March 8, 1916.**—A very interesting aurora borealis display was observed in Ann Arbor throughout the night of March 8. The sky was completely overcast until about 9 p. m. when it suddenly cleared. With the disappearing clouds the aurora showed itself in the form of a big arc, the summit of which was situated a little west of the due north. The lower edge of the arc was exceedingly well defined, and the part of the sky directly below it was darker than elsewhere. Several stars were visible in the dark segment, Vega being almost on the edge of the bright arc, which was rather intense and of a silvery or greenish white color. This last one extended with a decreasing brightness toward the top. Many rays were shooting from it, increasing considerably in length. Large fluctuations of light were noticed at various intervals, and toward the west, big nebulosities somewhat similar to cumulus clouds, were constantly changing in brightness. Many isolated bright patches appeared, very often near the zenith, lasting only a short time.

This auroral display put in its appearance at a time when activity on the sun's surface was very pronounced.

It was rather more intense than the aurora borealis which I observed in England last November and which happened at the time of the appearance on the sun of a group of three small spots, which became a very important group after a few days.

SUNSPOTS, MARCH 9, 1916.

The present aurora was probably related to the activity of two big spots of about equal size, one in the northern hemisphere and the other in the southern. A reproduction of these spots on a small scale is seen in the accompanying drawing, which I made at the Detroit Observatory.

Auroral displays have been frequent this winter. I have noticed sometimes in England, that although the sky was cloudy, they rendered moonless nights very bright. This, without doubt, comes about owing to the great solar activity corresponding to the maximum of sunspots.

F. HENROTEAU, D. es. Sc.

Detroit Observatory.
Ann Arbor, Mich. Mar. 9. 1916.

## GENERAL NOTES.

**Rev. Joel Metcalf** gave an illustrated lecture to the Field and Forest Club of Boston, at the Public Library on the evening of March 9. His subject was "The Growth of Worlds."

**Dr. W. S. Eichelberger** gave an address, as the retiring president of the Philosophical Society of Washington, on March 4 on "The Distances of the Heavenly Bodies."

**Dr. J. L. E. Dreyer** has been awarded the Gold Medal of the Royal Astronomical Society (England) for his contributions to astronomical history and his catalogues of nebulae.

**Sir F. W. Dyson,** the English astronomer, and Dr. C. S. Sherrington, professor of physiology at Oxford, have been elected corresponding members of the Petrograd Imperial Academy of Sciences. (*Science*, Mar. 3. 1916).

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**Mr. Thadée Banachiewicz** has recently left the Engelhardt Observatory, having been appointed an assistant at the Observatory at Dorpat and private lecturer in the University of Tourieff.

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**Mr. Dorsey Ash,** Berkeley. Cal., is the name of the person given the number "27" in the key to plate XXV published in the November, 1915, issue of POPULAR ASTRONOMY. This face was unidentified at the time of the printing of this group. Mr. D. S. Richardson, Secretary of the Astronomical Society of the Pacific, has kindly sent us the information.

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**The Van Vleck Observatory** of the Wesleyan University, Middletown Conn., is now practically completed. The Director, Professor Frederick Slocum, has promised us a photograph of the Observatory and a descriptive article of it for publication in POPULAR ASTRONOMY soon.

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### Two Spectroscopic Binaries.

| | Mag. | Spectrum | R.A. (1915) | Dec. (1915) | Range in Velocity, km |
|---|---|---|---|---|---|
| | | | h m | ° ′ | |
| Boss 4138 | 5.7 | F8 | 16 11.5 | +34 5 | Composite |
| 5996 | 5.9 | A2 | 23 14.1 | +41 19 | −86 to +10 |

The first of these stars is the brighter component of the well-known double star Coronae. On two of the spectrograms the spectra of both components appear and are very similar in character. A relative displacement between the components of nearly 140 km is indicated by the second of these photographs.

WALTER S. ADAMS.

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**An Interesting Case of two Stars of Common Motion.**—In a previous number of the Journal of the A. S. P. reference was made to the extraordinary radial velocity of the large proper motion star A.Oe. 14320. A second star with the same proper motion is distant from it 5′ in declination. Two observations of the spectrum of this second star have now been obtained. The results are as follows:

| | Mag. | Spectrum | R.A. (1915) | Dec. (1915) | μ | v, km |
|---|---|---|---|---|---|---|
| | | | h m | ° ′ | ″ | |
| A. Oe. 14320 | 9.2 | G4 | 15 5.5 | −15 57.5 | 3.76 | +295 |
| A. Oe. 14318 | 9.6 | G5 | 15 5.5 | −16 2.5 | 3.76 | +307 |

The photographs were taken with low dispersion and the accuracy of the determinations is relatively low. The radial velocities of the two stars may, therefore, be considered as equal. The absolute parallax of the stars is +0″.035 according to a

determination by Russell. Hence their distance from one another is about 8600 times the diameter of the earth's orbit, or about one thirtieth of the distance of α Centauri. We have, therefore, the interesting result that two stars separated from each other by an interval of the order of stellar distances are moving in precisely the same direction at a rate of about 580 km per second.

WALTER S. ADAMS.

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**The Magnesium Line λ 4571 in the Electric Furnace.**—In some experiments made in 1904 with a furnace consisting of a carbon tube tested by an arc playing on the outside, I observed a very high relative intensity of the Mg line λ 4571.275, one of the weaker arc lines, when magnesium was vaporized inside the tube. A recent study of the magnesium spectrum in the tube resistance furnace at different temperatures has confirmed this observation and shows a striking contrast between this line and neighboring lines of magnesium. At 1950° C, λ 4571 is of nearly the same intensity as λ 5184, the strongest member of the *b* group, while the strong arc lines λλ 4352 and 4703 have not appeared. At temperatures above 2200°, while the arc lines are gradually developing, λ 4571 is liable to appear in absorption, its tendency to reverse being comparable with that of the calcium line λ 4227. λ 4571 remains narrow, however, and when in absorption does not show distinct emission wings in the photographs thus far made, indicating that the line may not be given by the hot vapor in the middle of the tube. At any rate, a decided strength for λ 4571 seems a clear indication of a low temperature condition.

ARTHUR S. KING.

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**The Chabot Observatory Dome as Wireless Aerial.**—The following note, taken from the Oakland (Cal.) *Tribune* for February 19, 1916, describes a novel method of receiving wireless signals at the new Chabot Observatory.

"Wireless flashes caught by the steel dome of the Chabot Observatory in the Oakland hills bring Oakland the correct time daily, as the result of one of the most remarkable tricks in wireless telegraphy ever attempted on the Pacific coast. Having no funds to erect wireless apparatus for catching the time signals from Mare Island, Charles Burckhalter, director of the observatory, and City Electrician James Tudhope have fastened their apparatus to the steel shutters of the dome, which picks up the aerial messages, transmitting to the delicate machinery of the time-dividers the ticks of the Mare Island instrument, actuated from the government observatory.

"The wireless time will be used in the work of obtaining the exact latitude and longitude of the new observatory, which must be determined to a hair to reach correct results on delicate observations. The location of the old observatory was established in 1888 by Professor Davidson and Myron Sinclair. Experts from the coast survey will establish the latitude and longitude of the new observatory next year.

"Needing a wireless apparatus to receive the Mare Island time, Burckhalter consulted with Tudhope, planning to erect aerials. Noticing that the big dome was insulated, Tudhope conceived the idea of using it as its own antenna, and the experiment proved a perfect success. The wires are fastened to the moving machinery of the dome and grounded by a gas pipe."

**Popular Astronomical Errors.**—One hardly knows whether to be more impressed by the humorous or the pathetic, and so whether to laugh or cry, over popular mistakes made by many who venture into the field of Astronomy. There is the artist, for example, and sometimes a famous one, who paints a wonderful sunset scene, with the narrow crescent of the new moon dropping in the west, its horns turned the wrong way, toward the setting sun instead of away from it. Not a few artists seem to think that the position of the crescent is a matter of indifference. There is also the artist who shows the full moon high in the sky, when it must be near midnight, possibly even past that hour, and yet various activities of men going on, mothers out with their children, etc.

Whenever any unusual celestial phenomenon occurs interesting the popular mind, the journalist finds it necessary to explain and offer comments, and the result is sometimes very ridiculous. The February eclipse of the sun brought out some such matter, it being gravely announced that, in certain regions, at the maximum, the sun would be one third covered by the moon. Evidently what was meant was that the moon would cover one third of the sun's diameter; but, this being done, the moon's curved outline would leave much more than two thirds of the sun's surface exposed. One has only to draw a rough picture to see this at a glance, as Professor Rigge's pictures do in the January POPULAR ASTRONOMY, dealing with that eclipse.

One newspaper, which fell under the writer's observation, in describing the February solar eclipse, told at what time observers might see "the shadow" coming across the face of the sun. I should like to ask the editor what his idea of a solar eclipse is, and what body it is that casts its shadow on the sun's face, in his opinion. He would probably answer that it is the moon's shadow. Then I should like to remind him that it is a light that casts a shadow, and to ask what light casts the shadow of the moon upon the sun's face when the latter is eclipsed. I imagine that he would hesitate before venturing on an answer, although doubtless some would even commit the blunder of saying that it is the sun's light: and thus they would make a light cast a shadow of a body back upon itself. It is easy to believe that many otherwise intelligent people, when they view an eclipse of the sun, do not realize that they are looking not at a shadow, but at the solid body of the moon, passing between the sun and the earth.

In speaking of the same eclipse, a certain paper remarked that eclipses of the moon are also of interest, particularly when seen at night. While it is true that we often see the moon in the sky by daylight, the editor needs to be instructed that no lunar eclipse was ever seen, except at night. When sun and moon are both in the sky, how is the sun to cast the earth's shadow upon the moon? The latter is never eclipsed except when at full; and full moon is never seen in the sky at the same time with the sun, for it is necessarily opposite the sun. When the full moon rises, and so comes into view, the sun sets, and so disappears; then night comes on: and only at night can the moon be seen eclipsed.

At the close of a lecture, when I had invited the audience to ask questions, one of my listeners came to me to inquire whether the moon were not "just a light in the sky." The meaning of the question seemed to be that the moon is not a material body, but a mere light. How the questioner would account for a light without a body as the basis of the light, is a mystery. Light alone, while real, is invisible. We cannot see the light traveling between sun or moon and earth. The illuminated sun or moon can be seen, because illuminated; but if either of them were removed, its light would go with it. This is proved by every sunset and every moonset.

FREDERICK CAMPBELL.

Beaver Falls, N. Y.

**Actual Time of Signals from the U.S. Naval Observatory, February, 1916.**

| Day | Time of signals Noon | | | Error | Time of signals 10:00 p.m. | | | Error | |
|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | | h | m | s | | |
| 1 | 12 | 0 | 0.01 | +.01 | 10 | 0 | 0.00 | .00 | |
| 2 | 12 | 0 | 0.02 | +.02 | 10 | 0 | 0.02 | +.02 | |
| 3 | 12 | 0 | 0.03 | +.03 | 10 | 0 | 0.03 | +.03 | |
| 4 | 12 | 0 | 0.02 | +.02 | 10 | 0 | 0.03 | +.03 | |
| 5 | 12 | 0 | 0.08 | +.08 | 10 | 0 | 0.09 | +.09 | |
| 6 | 12 | 0 | 0.12 | +.12 | 10 | 0 | 0.15 | +.15 | Sunday |
| 7 | 12 | 0 | 0.17 | +.17 | 10 | 0 | 0.19 | +.19 | |
| 8 | 12 | 0 | 0.20 | +.20 | 10 | 0 | 0.08 | +.08 | |
| 9 | 12 | 0 | 0.07 | +.07 | 10 | 0 | 0.09 | +.09 | |
| 10 | 11 | 59 | 59.99 | −.01 | 9 | 59 | 59.99 | −.01 | |
| 11 | 11 | 59 | 59.99 | −.01 | 9 | 59 | 59.97 | −.03 | |
| 12 | 11 | 50 | 59.99 | −.01 | 9 | 59 | 59.98 | −.02 | |
| 13 | 11 | 59 | 59.99 | −.01 | 9 | 59 | 59.99 | −.01 | Sunday |
| 14 | 11 | 59 | 59.98 | −.02 | 9 | 59 | 59.98 | −.02 | |
| 15 | 12 | 0 | 0.01 | +.01 | 10 | 0 | 0.01 | +.01 | |
| 16 | 12 | 0 | 0.02 | +.02 | 10 | 0 | 0.02 | +.02 | |
| 17 | 12 | 0 | 0.04 | +.04 | 10 | 0 | 0.04 | +.04 | |
| 18 | 12 | 0 | 0.05 | +.05 | 10 | 0 | 0.04 | +.04 | |
| 19 | 12 | 0 | 0.07 | +.07 | 10 | 0 | 0.07 | +.07 | |
| 20 | 12 | 0 | 0.07 | +.07 | 10 | 0 | 0.08 | +.08 | Sunday |
| 21 | 12 | 0 | 0.09 | +.09 | 10 | 0 | 0.11 | +.11 | |
| 22 | 12 | 0 | 0.02 | +.02 | 10 | 0 | 0.03 | +.03 | |
| 23 | 12 | 0 | 0.01 | +.01 | 10 | 0 | 0.01 | +.01 | |
| 24 | 12 | 0 | 0.02 | +.02 | 10 | 9 | 0.02 | +.02 | |
| 25 | 12 | 0 | 0.04 | +.04 | 10 | 0 | 0.02 | +.02 | |
| 26 | 11 | 0 | 0.05 | +.05 | 10 | 0 | 0.04 | +.04 | |
| 27 | 11 | 59 | 59.98 | −.02 | 9 | 59 | 59.99 | −.01 | Sunday |
| 28 | 11 | 59 | 59.99 | −.01 | 10 | 0 | 0.01 | +.01 | |
| 29 | 12 | 0 | 0.03 | +.03 | 10 | 9 | 0.04 | +.04 | |

Maximum error: Feb. 8, +0.20 sec.

Constant to be added to above errors to give error of radio signals from

Arlington +0.02 sec.

Key West +0.27

J. A. HOOGEWERFF,
Captain U.S. Navy
Superintendent

U.S. Naval Observatory,
Washington, D. C,
Mar. 3, 1916.

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**The Production of Certain Banded Spectra in the Electric Furnace.**—Experiments have recently been made with the electric furnace to obtain evidence on the origin and observe the behaviour at various temperatures of the banded spectra which have been ascribed by Fowler and others to titanium oxide, magnesium hydride and calcium hydride, respectively. All of these bands occur in sun-spot spectra, and the probability that the first named, the "Antarian bands," are due to titanium oxide has been taken as indicating the presence of oxygen in the Antarian stars as well as in the sun.

It was noted in a previous investigation that these Antarian bands do not appear when titanium is vaporized in the furnace in vacuum. The present work was undertaken to see if the presence of oxygen would bring out the bands in

the furnace as it does in the arc. Tests with air in the furnace chamber at one-half atmosphere and the atmospheric pressure did not give the bands. It seemed, however, that this might indicate simply a lack of oxygen in the furnace tube due to its carbon immediately using up the oxygen of the contained air, there being little circulation through the horizontal tube. The windows of the furnace chamber were therefore removed, and a plentiful supply of air was introduced directly into the tube by means of a silica tube attached to a bellows. The band spectrum then appeared with great intensity. Although pure oxygen has not yet been tried in the furnace, it is fairly certain that the banded spectrum is brought out by the oxygen of the air, since it has been found with the arc that an atmosphere of nitrogen suppressed the bands.

When the bands were made strong in the furnace, the line spectrum, at least in the yellow and red region under examination, was rendered very faint, as if all the titanium vapor were turned into the oxide and this gave the band spectrum alone. No decided change in temperature was evident when air was used in the tube.

It may be noted that this use of the furnace produces what may be regarded as a very hot flame spectrum, since the metallic vapor in the tube is raised to a high temperature and the oxygen is then supplied for the flame effects.

Experiments with the furnace in vaporizing magnesium and calcium in an atmosphere of hydrogen confirms the arc results as to the effect of hydrogen in bringing out the bands ascribed to the hydrides of these elements. Both sets of bands can be produced faintly with the furnace pumped out, but the spectrum of the "tube-arc" has shown that considerable hydrogen is present under such conditions, probably occluded by the graphite tube. The use of hydrogen in the furnace chamber at different pressures and temperatures gave rather variable results until the method was adopted of passing a stream of hydrogen through the furnace tube during the exposures, the pressure in the chamber being maintained at from 10 to 20 cm of mercury. The bands were then obtained moderately strong without, however, any perceptible weakening of the line spectrum. The best defined bands in these bands are at λλ 4845, 5211, 5621 for magnesium and λλ 6382, 6289 for calcium. A temperature not higher than 2200° C seemed to be most favorable for them. At 2500° the bands were weaker and were liable to appear in absorption, as if they were given by the cooler vapor near the end of the tube.

These results indicate that the strengthening of the titanium, magnesium, and calcium bands by the presence of oxygen or hydrogen, observed in the arc experiments, does not depend on an alteration of the arc discharge by the surrounding gas, and point to the formation of a compound at moderate temperature in each case.

ARTHUR S. KING.

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**The Maharaja's Observatory at Trivandrum.**—The existence of an Astronomical, Magnetic, and Meteorological Observatory at Trivandrum may not be widely known, as it ought to be, outside India, as its name does not appear in any of the Nautical Almanacs published. With a view to draw the attention of the scientific, especially the Astronomical world, I consider it necessary and beneficial, in the interests of the Institution, to request you to insert a short article regarding this most useful institution, in the next issue of your widely circulated Monthly

though it may be after 80 years of its chequered life.

Subjoined I give you, for your information, a few salient points connected with its growth.

The institution owed its origin, in 1835, to the enlightened views of His Highness Rama Varma, the then Maharaja of Travancore and to the encouragement given to it by the late General Stuart Fraser, an Astronomer, then representing the British Government at Trivandrum, the capital of the State. It was Mr. John Caldecott, then Commercial Agent to the Travancore Government at the important sea port town of Alleppey, that first brought to their notice the advantages that might accrue to science by the establishment of an Institution like this, in the most southern part of the Indian Peninsula.

It is considered to be a very important one, being very favourably situated, in the language of a former eminent Dewan of the State, "for the purpose of many scientific enquiries." Mr. John Caldecott in the concluding remarks to his Astronomical Ephemeris for 1837 adapted to the meridian of the Trivandrum Observatory—the only production of its kind in India then—"expressed his earnest hope that this Observatory might take an important part in celestial research and prove useful to science." And Mr. John Allan Broun the next Director wrote in his able report that it offered special advantages in the department of terrestrial Physics, or generally terrestrial magnetism, as the Magnetic equator passes through the country" about 90 miles north of the Trivandrum Observatory.

It is provided with all the necessary and some very valuable instruments required for equipping a first class Institution, though old yet mostly in working condition, while some have been otherwise disposed of and a few become unworkable, through long disuse.

Mr. John Caldecott F. R. S., F. R. A. S., a distinguished Astronomer and its first Director and his successor Mr. John Allan Broun F. R. S. formerly of Makerston Observatory near Edinborough and subsequent to his retirement, two native Assistants J. Kochukunju and E. Kochiravi Pillai conducted a series of very valuable Magnetic observations for a number of years. These observations were acknowledged to be of great scientific value and were subsequently checked, and on the representation of the Royal Astronomical Society of Edinbourgh, published in England, in a splendid volume by Mr J. A. Broun, at the cost of the Travancore Government. The Meteorological observations were published by the Meteorological Department, under the authority of the Government of India, in a series of periodical issues forming volumes VII, VIII X of the "Indian Meteorological Memoirs."

Long after the retirement of Mr. J. A. Broun, the Observatory was placed under the guidance of Dr. Mitchel F. R. S. E., Principal of His Highness The Maharaja's College and afterwards Director of Public Instruction, Travancore; and on his retirement from the Travancore service, Mr. Joseph Stephenson B. Sc., his successor in the chair of Physics in the Royal College, took charge. He is now on furlough for one year; and during the period, the Institution is under the management of the Assistant Director, Mr. Rama Varma Raja, who is a born astronomer and "a lover of his work."

The work done in the Observatory consists of:—

(a) taking Meteorological and Magnetic observations and publishing the results weekly in the Travancore Government Gazette;

(b) despatching daily Weather Telegrams to Madras, Bombay and Simla Meteorologists;

(c) compiling Meteorological statistics of Travancore and sending to the Meteorologist, Madras for incorporation in his daily, monthly and annual Reports;

(d) firing, morning, noon, and night time guns at the Nayar Brigade ground, half a mile distant, by means of an electric attachment placed in front of the Mean Solar Time Clock in the Observatory, corrected and reduced by Transit observations. The error of the clock is + .5$^s$ a day; and

(e) Making Astronomical observations from time to time.

The Trivandrum observatory is geographically located

in Lat. +8° 30′ 33″ N

Long. from Greenwich — 5$^h$ 7$^m$ 59$^s$ East, reckoned by the first Director, Mr. John Caldecott. The height of the surface floor above the sea level is 197 ft.

The building is put up on the crown of a conical hill commanding an extensive and beautiful view of the surrounding country up to the sea on the west and on the east the Ghauts, in one of the highest peaks of which, known as the Agustia Malai 6200 ft. above sea level, in Lat. 8° 37′ North and Longitude 77° 20′ east of Greenwich, stood another Observatory from which many observations by means of signalling, were simultaneously taken, and embodied in the Report of Mr. J. A. Broun and in the Indian Meteorological Memoirs Vol. X.

RAMA VARMA RAJA.

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## Publications Received.

The Field of 61 Cygni, *Mary Murray Hopkins.*

The Amateur Chronologist, *F. Grade.*

Publications of the Dominion Observatory, Ottawa,

Vol. II, No. 10, Gravity

11, Tests made to ascertain where conditions were most suitable for the 72-inch reflector.

12, Mean distance of stars whose radial velocities, proper motions and parallaxes have been determined.

13, Orbit of B. A. C. 5890.

14, Orbit of $\mu$ Persei.

Publications of the U. S. Naval Observatory, second series, Vol. IX, Part II, nine-inch transit circle observations, 1903-1908.

Clock star list for 1916, Royal Observatory, Greenwich.

Arequipa Pyrheliometry, *C. G. Abbot.*

The variation with temperature of the electric furnace spectra of cobalt and nickel, *Arthur S. King.*

Studies of magnitude in star clusters I. On the absorption of light in space. *Harlow Shapley.*

Studies of magnitudes in star clusters II. On the sequence of spectral types in stellar evolution. *Harlow Shapley.*